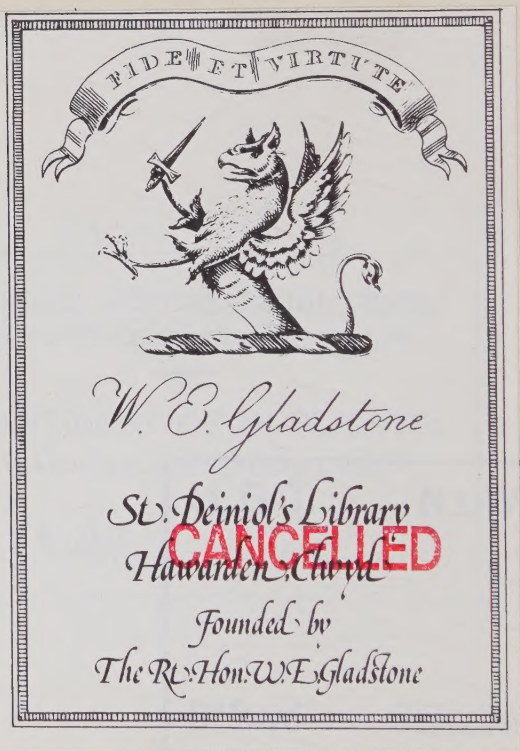

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THE COAL INDUSTRY

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Mines and Minerals

Early transportation methods. Women carrying coal from the mines in baskets supported by a leather strap across the forehead.

Frontispiece (Fig. 2). *See page* 43

THE COAL INDUSTRY

BY

A. T. SHURICK

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Dedicated

IN THE

PUBLIC INTEREST

TO THE

COAL INDUSTRY

PREFACE

THE actuating motive back of the idea upon which this book was conceived could not be more forcibly expressed than in the words of the U. S. Coal Commission wherein it states, "The first step toward protection of the public interest is a better public understanding of the coal business. Guided by facts rather than rumors, by information rather than prejudice, the people will be able to exercise wisely the powers of the government."

Perhaps none of the great basic industries bears so directly upon the welfare of the average man, or has been so persistently in the public eye, as has the coal industry. If to this we add an astonishing propaganda, emanating from sources with large issues in the balance, it is not to be wondered that the final result has been a potpourri of misinformation that has left the average citizen in a maze. It was largely in recognition of these conditions that official Washington decided to unearth the fundamental cause of the trouble by initiating one of the greatest fact-finding researches in the history of the country — the U. S. Coal Commission.

In taking up our study of the industry we must first accept it as axiomatic that there is something inherently wrong with it. In fact, we are dealing with a very sick man, in evidence of which we have no less an authority than Herbert Hoover who once characterized the coal

industry as "the worst functioning of any industry in the country." The troubles are legion and involve all branches of science and philosophy, our responsibility to future generations, legal and technical problems, stupendous questions in economics, transportation and finance for which we have no precedent, together with a death grapple between capital and labor on a scale never heretofore contemplated. The whole is shrouded in a maze of intricacies which overlap and intertwine in a manner that makes it exceedingly difficult to untangle the various threads and follow them through to a logical conclusion.

There are many able works in the coal literature dealing with these different problems from a technical point of view with a detail and thoroughness that leave nothing to be desired, but there has never yet been an attempt to straddle the whole field with a single volume designed specifically for the layman. The eight hundred thousand word report of the U. S. Coal Commission is substantially the most important source of vital information we have on the industry. The personnel of this commission was such as to preclude any suspicions of ulterior motives and their opinions were rendered with a gratifying impartiality that is enduring evidence of their sincerity and good faith. The professional student of the coal industry cannot improve on the mine of information that is to be found in the eight large volumes that go to make up this report (if, and when published), though the average reader will experience some difficulty in interpreting the results in every case. The highly technical nature of the investigation has necessarily limited the report to an equally technical presentation, as is indicated by such occasional references as the report has not been "prepared for the casual reader, but for the serious student

who desires to study all of the elements in the industrial situation."

The author has been entirely untrammelled by exterior influences or ulterior motives and has not evaded any of the issues, or sought to conciliate any of the interests concerned. We must, for instance, recognize the hopelessly irreconcilable nature of the conflicting claims of capital and labor and to accept either of these *per se* would destroy the fundamental idea on which the book was conceived. A painstaking effort has been made to elucidate the philosophy upon which the contending principals build their respective cases in order that the reader may comprehend what might otherwise seem incredible. This should not be construed as an effort to condone or justify certain practices of either side; instead, it is only an attempt to show the gradual development of the state of mind which ultimately gave the actuating impulse to these practices which, if presented unadorned, would be difficult to understand. The faults and virtues of both sides have been dealt with impartially and since neither is disposed to accept any estimate of the situation other than an unqualified recognition of its own views, it is fully anticipated that the book will be charged with "pro-ism" from both.

A studied effort has been made to maintain a proper balance throughout the book with a view to presenting a composite picture from the mine to the consumer's bin, with a proper perspective of the relative importance of the different functions. The reader with a special hobby is particularly cautioned to remember that this is not a treatise on geology, rail tariffs, engineering, sociology, or any of the hundred other topics that go to make the completed work. The author is keenly alive to the difficulty of subordinating that in which he is particularly

interested to something of greater significance and a definite effort has been made to overcome such failings. The fundamental thought back of the book has been to present an accurate, comprehensive picture of the characteristic phases of the industry without encumbering it with too much detail or an excessive amount of technical or statistical matter.

A compilation of this scope would, of course, be impossible except by drawing upon all available sources of information, and the author wishes in particular to acknowledge his indebtedness to the publishers of the *Engineering and Mining Journal-Press*, of *Coal Age*, and of its predecessors the *Colliery Engineer* and *Mines and Minerals* for the bulk of the excellent illustrations used herein, the standard of which is unexcelled by any technical journals in the world to-day. The U. S. Geological Survey and the U. S. Bureau of Mines have both been drawn upon liberally for data, statistics, etc., in their respective fields. The *Transactions* of the American Institute of Mining Engineers and those of a number of the local mining institutes and the *Black Diamond* have all furnished certain quotas and some matter has been excerpted from the technical press abroad.

A. T. Shurick

Athens, Ohio,
January 29, 1924.

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PART ONE

THE COAL FIELDS

THE COAL INDUSTRY

CHAPTER I

Discovery of Coal

The discovery and first use of coal is shrouded in as much mystery and uncertainty as the discovery of fire itself. The promiscuous distribution of coal beds in all corners of the world makes it difficult to believe that the primitive man could have lived many centuries before he stumbled upon this providential aid to his comfort and well-being. Certainly the early fire worshipers, and others burdened with the responsibility of keeping permanent fires, because of the difficulty of starting these, must have been quick to seize upon this surcease to their troubles.

It is not unreasonable to believe that coal came into at least a limited use with the discovery of metals, because of the more intense heat required in working these. If it did, however, it became one of the lost arts again, as charcoal was afterwards used exclusively for this purpose until comparatively modern times. But on this hypothesis coal may have been used in the Bronze Age, around 3000 to 8000 B.C., or more likely in the Iron Age, about 1000 B.C.

The first authentic record we have of the use of coal is that of Theophrastus, who notes the application of it for smithing purposes in Greece in the year 300 B.C. Biblical references to the use of coal are unsatisfactory from a

scientific standpoint because of the difficulty in distinguishing whether these referred to coal or charcoal; most if not all the "coals" mentioned in the Bible appear to refer to the latter.

Coal was mined quite extensively in England during the Roman invasion but the earliest authenticated record of its use there is in A.D. 852. It was three centuries after this before anything approaching systematic mining was developed, but at the end of the thirteenth century coal had come into general use at Newcastle and was being exported to some extent.

Our ancestors of that day were, however, deeply suspicious of this new fuel with its heavy smoke and pungent odors. Fears were entertained that it was a menace to the public health and so widespread did these become that the English king prohibited the mining of coal entirely. France immediately followed suit with a like prohibition and it was the middle of the sixteenth century before coal came into general use in Paris.

In the meantime the mining and use of coal had been spreading throughout Europe and Asia. Scotland began producing in the twelfth century and Germany in the thirteenth. History is vague regarding the discovery of coal in China but with her abundant resources of excellent fuel and the natural inventive genius of her populace, she was probably mining coal long before Europe was.[1]

It is a strange anachronism in the history of our own industry that the first authenticated discovery of coal was not made until two centuries after Columbus landed, and then at a remote and comparatively unimportant field, far in the interior. But such is the case. Our early forefathers constructed trails over the numerous rich coal

[1] "The Chinese . . . used coal and gas heating centuries before these things were used in Europe." — H. G. Wells, "Outline of History," Vol. 1, p. 635.

seams of the Appalachian Mountain regions in apparent ignorance of their existence, and finally sent back a report of coal from the town of Ottawa on the Illinois River in the year 1679.

Almost another century elapsed before we have authentic record of actual mining operations. These workings, the oldest of which there is any record, were started in the Richmond bed twelve miles above Richmond, Virginia, in 1750. Coal came into general use in that vicinity during the next twenty-five years and by 1789 it was being shipped to Philadelphia, New York, and even so far as Boston.

This marked the beginning of a period of rapid discoveries. In 1755 General Braddock built a military road into the Pennsylvania fields which cut the coal seams in many places and, while no official record of coal was made, there can be no doubt that it was seen and its importance recognized. Five years later the Rhode Island anthracite field was discovered, though this was never destined to be of commercial importance because of its inferior quality.

The Pittsburgh district, with its fabulous reserves of the best quality coal, was the next field to receive attention, mining operations being initiated there in 1760 and shipments made to Philadelphia early in the nineteenth century. The first discovery of anthracite was reported two years later, in 1762, in the vicinity of Wilkes-Barre, Pennsylvania, a field that was destined to be the largest and most important in the anthracite industry. The discovery of the near-by Southern and Middle anthracite fields did not occur till considerably later, the former in 1791 and the latter in 1826.

Such is the history of the discovery of coal in America. The early pioneers, drifting in their crude rafts down the Ohio River and then working up the Mississippi, later

reported coal showings in Ohio, Indiana, and Illinois, the first discovery having already been noted in the latter State. The great Appalachian field, extending from Pennsylvania to Alabama, was disclosed little by little as the frontiersmen pushed their way back from the coast into this almost impenetrable wilderness. A French map, dated 1782, but made from data previously obtained in this country, shows the location of a coal mine in the now famous Georges Creek field of Maryland.

Lewis and Clark were the first white men to learn of the presence of coal in the Northwest, though they had little conception of the enormous extent of these reserves. The Wyoming fields were first reported by Fremont in 1843 and the earliest examination of the Montana region was made by members of the Transcontinental Survey in 1879. Coal mining was started in Colorado in 1863 at the town of Marshall, five hundred tons being shipped out of there the year following.

CHAPTER II

The Embryonic Stage

There is a well-defined interval between the early discoveries of coal and the beginning of commercial operations which belongs properly to neither of these times, and yet is of peculiar interest to the student of the coal industry. The transitional period between these two episodes was one great travail to the pioneers of the coal industry; it required an almost superhuman effort not only to mine and transport the coal to the market centers, but to educate the consumers in the methods of burning it as well. It was a time of great confusion and uncertainties, of economic losses and wasted effort, and though the industry emerged triumphant in the end, these early pioneers as a rule profited but little from their labors.

One of the greatest difficulties encountered in the development of the anthracite fields, and which delayed this development for an appreciable time, was in making the coal burn. The consumer who has used this fuel knows the special treatment that is necessary to start a fire, but it was some time before this was discovered. Thus while anthracite coal was found in 1762, the first record of its having been successfully burned is seven years later, in 1769. This was accomplished in a blacksmith's forge under forced draft and for more than a quarter of a century longer it was thought that this was the only way in which it could be burned.

The first authentic record of anthracite being successfully burned in a stove is in 1802, and an entirely different and equally successful effort is reported in the Wyoming

region in 1808. One of the interesting legends connected with this phase of the industry is that of a very determined effort to make an anthracite fire in a small iron furnace. It is reported that the men worked unceasingly for a day and a night but gave up in disgust on the morning of the second day and, slamming the furnace door shut, went home to breakfast. Later one of the men returned for a forgotten garment and was amazed to find a seething fire in the furnace. Thus was learned the important lesson in making an anthracite fire — let it alone.

Having finally satisfied themselves of the practicability of burning anthracite coal, the miners started with great enthusiasm to formulate plans for shipments to the consuming centers. But their first attempts, undertaken in the face of almost insuperable obstacles in transportation, were abortive; consumers already had a satisfactory source of supply and where the coal was tried out it usually proved a failure because the stoves were not properly constructed for it. These early ventures resulted in losses to all concerned and much of the coal, transported at such great effort and expense, was ultimately used for making sidewalks at the points of destination.

But some of the more persevering of these early pioneers were still undismayed. They returned home and laid new plans for approaching the consumers. Fresh cargoes were again soon en route to market and with these went stoves specially made to demonstrate burning the coal. Press agents were sent ahead and announcements printed and distributed proclaiming the virtues of the new fuel. Public interest was aroused and when the coal arrived the stoves were set up in the streets and demonstrations given to the curious crowds that gathered around them. Curiosity soon verged into interest. A vigorous house-to-house campaign followed and the public bought.

And so, about the year 1808, we find a regular trade in existence with towns along the banks of the Susquehanna River. In 1812 shipments were made to Havre de Grace at the mouth of the river and thence by schooner to New York. The trade continued to expand and increase, some eighty-five thousand tons in all being sent down the river, up to 1830. With the completion of the North Branch Canal in that year and the construction of the Lehigh and Susquehanna Railroad in 1846, we enter the new era of large-scale operations which will be taken up elsewhere.

Shipments from the Southern anthracite region down the Lehigh River to Philadelphia were made as early as 1803, but although this was some five years before the Susquehanna trade was started, the former did not prosper in the same way as the latter. In fact, it was not until 1814 that special conditions, incident to the war, created a scarcity of Virginia coal in Philadelphia and gave the anthracite mines a foothold in that market. The trade again lapsed after this but was resumed once more in 1820 with a shipment of 365 tons and continued to increase from then on until the Pennsylvania Canal was completed into the mining regions in 1831, when 40,966 tons were shipped out.

The first effort to obtain an outlet from the anthracite regions that would handle this trade on a comprehensive scale was that initiated by the Delaware and Hudson Company in 1823. This company was incorporated in that year to construct a canal from Roundout on the Hudson River to Port Jervis on the Delaware, in order to provide an outlet for coal from the Northern anthracite regions to New York. The plan contemplated utilizing the Delaware River from Port Jervis to Honesdale, at which point it was proposed to cross the towering heights of the Moosic Mountains by means of a series of hoisting

planes with stationary engines to haul the cars up and down and so reach the coal fields. It was a bold undertaking for those days of limited capital, involving as it did many almost overwhelming construction difficulties. The canal was completed in 1828 and shipments started to tidewater in 1829 and the project stands to-day as a monument to the industry and perseverance of its creators.

Other projects of a similar nature now followed in rapid succession, the Reading Company obtaining a charter for a railroad into the Southern anthracite region in 1833, and running its first train in 1839. So we pass on to the present-day stage of operations in the anthracite field.

Coal land values in the early days of the anthracite industry ranged from twenty and thirty dollars to one hundred dollars per acre. By 1890 these values had increased to twelve hundred and fifteen hundred dollars an acre and to-day it is difficult to say what they are worth, as will be shown later. The Philadelphia and Reading Company purchased one hundred thousand acres of anthracite coal lands in 1871 for forty million dollars. Coal leases on a royalty basis were negotiated in 1870 at ten cents per ton; in 1890 these had increased to an average of twenty-five to thirty-five cents per ton, with some being made at forty-five and fifty cents per ton. Leases to-day are bringing as much as a dollar and a half per ton. The Girard Estate, which leases some four thousand acres to the large operating companies in the anthracite regions, realizes about six hundred dollars an acre on its holdings each year.

Originally the anthracite coal lands were divided up into many small holdings and it is a mournful fact that these early pioneers realized but little on their land. Once mining was started it soon became evident that it

was not a poor man's business; working to the dip (and most of the anthracite seams are very heavily inclined) necessitated an immediate expenditure for mechanical equipment to hoist the coal and pump the water. As the workings progressed to greater depths, this became steadily more accentuated and further complications were introduced in the equipment necessary for preparing the coal. So we find the small operator being rapidly supplanted by the larger who had adequate financial means and engineering talent to cope with these increasingly difficult problems.

Activities in the bituminous fields in the meantime had been keeping pace with those in the anthracite regions. We have already noted the arrival of coal from the Richmond bed in Virginia at Philadelphia in 1789, where it was coming into successful competition with the British product from overseas. The Pittsburgh coal was also in this market early in the following century, and with the construction of the National Turnpike in Maryland in 1814, we find coal from the famous Georges Creek region beginning to appear in Baltimore in wagon lots. Coal was also being floated in barges down to Georgetown and Washington, this business assuming some importance by 1820, and continuing until the Baltimore and Ohio Railroad was built into Cumberland in 1842.

The preëminence of the Georges Creek coals was recognized at a very early stage in the coal industry and even at a time when consumers were far less discriminating as to quality than they are now. The field was among the first of the important mining regions to be actively developed and has the further distinction of being the birthplace of the Consolidation Coal Company, the largest bituminous coal company in the country to-day. The history of the development of this field is typical of that

in nearly all fields, and it is of interest to follow this through the various stages of the initial activities.

With the advent of the Baltimore and Ohio Railroad into the field in 1842 a great impetus was given to the mining industry. In the meantime the Chesapeake and Ohio Canal, which was started at the same time as the railroad — in 1828 — was completed between Cumberland and Georgetown in 1850, after a somewhat stormy financial career and an expenditure of eleven million dollars. We thus find the field enjoying rather unusual transportation facilities by the middle of the nineteenth century, at least as compared with other coal regions.

The first coal company to be organized in this field, the Maryland Mining Company, came into existence in the same year that ground was broken for the construction of the railroad and the canal, in 1828. This was followed by the organization of the Georges Creek Coal and Iron Company in 1835 and the Maryland and New York Mining Company in 1838. All of these companies encountered hard going in a financial way and failed, the last two being ultimately absorbed in whole, or part, by the Consolidation Coal Company after it was organized in 1860.

The advent of adequate transportation facilities into the field witnessed a very extensive broadening in mining operations, with the result that production soon outstripped market requirements. The operators were obliged to cut prices to hold their trade and an era of aggressive competition developed that drove some of the companies out of business. In 1869 the situation had become so acute that five of the leading companies endeavored to effect a consolidation of the operating interests with a view to maintaining prices on a profitable basis and reducing costs, but the plan failed.

In the meantime the Consolidation Coal Company, with its excellent financial resources, had been forging to the front and by 1870 it controlled more than half of the Georges Creek field. It had absorbed the Mt. Savage Iron Company (the successors to the Maryland and New York Mining Company), the Cumberland and Pennsylvania Railroad, which had originally belonged to the Georges Creek Coal and Iron Company, the Frostberg Mining Company, the Ocean Steamship Company, the Cumberland Coal and Iron Company, and about five years later the Allegany Mining Company. The enlarged company was able to effect economies in operation and improvements in selling that put it on a sound financial basis and gave it a certain control over the market. It was thus able to dominate the field and get the business established on a profitable basis which has been generally maintained up to the present time.

Mining in the West Virginia fields on any important scale was first initiated in the Kanawha Valley and its tributaries, most of the product being used locally at first to manufacture salt. About two hundred thousand tons per annum were being produced in 1835 and the operators were already looking for an outlet into other markets. With the discovery of the rich cannel coals in Coal River about 1840, the companies interested in this district made extensive improvements in the river which gave them an outlet to the Kanawha. A very profitable trade was worked up for these coals at points along the Ohio River but the mines and improvements were destroyed during the Civil War and mining was not revived there again until recent times.

Systematic explorations farther up the Kanawha Valley had begun in 1849, and in 1853 operations were started on Fields Creek, and four years later on Paint Creek.

The coal was hauled to the Kanawha River, where it was loaded on barges and sent down the Ohio River as far as Louisville and Cincinnati, a precarious and hazardous journey, resulting in frequent disasters. In later years the Kanawha River was improved and coal shipped from this district as far as New Orleans. The opening of the modern trade of the Kanawha Valley began with the advent of the Chesapeake and Ohio Railroad in 1873.

The Pocahontas field did not obtain railroad facilities until 1882, shipments to the seaboard beginning the year following, and with the construction of the Lamberts Point Pier in 1885 the coastwise trade was started. Shipments to New England had been made previous to this, however, the first cargo of West Virginia coal arriving there on September 1, 1876. Two years later a cargo of 397 tons of New River coal, shipped by way of the Chesapeake and Ohio Railroad and Richmond, Virginia, was sent to Boston, where it came into competition with the Pennsylvania coals that were already being received there in the small five-ton cars of that day. This was the beginning of a long rivalry between those two fields which persists to this day.

CHAPTER III

The Coal Fields

The coal fields of the United States are commonly divided into seven major regions, distinguished by their geographical location, and sometimes with no distinct line of demarcation between contiguous regions. These major divisions, in the general order of their location from east to west, and also in the approximate order of their commercial value [1] are:

Anthracite Region
Eastern or Appalachian Region
Middle Western Region
Western Region
Southwestern Region
Rocky Mountain Region
Pacific Coast Region

Each of these major regions has been subdivided into many supplementary districts and these latter not infrequently broken up into still further subdivisions. These smaller subdivisions are usually due to variations in the quality of the coal, thickness of the seams, etc. An excellent example of how fields are thus subdivided is seen in the Pittsburgh district, which is itself a subdivision

[1] The order of commercial value follows the geographical order here for the reason that the progress is from the older and richer Carboniferous measures of the East to the more recent and leaner Cretaceous coals of the West. Age is not the final determinate in fixing the value of a coal, but other conditions being equal, the older coal will be the best.

of the Eastern or Appalachian region. The western section of this field is known as the Panhandle region; east of this, and gradually merging into it with no distinct line of demarcation between, is the Gas Coal field with the Westmoreland Gas Coal field to the north and the Klondyke Coke field to the east, and finally the Connellsville region on the eastern border. The fields often overlap each other and this is frequently the source of a great deal of confusion in commenting upon various coals.

THE ANTHRACITE REGION

The anthracite coals are confined to a very limited area in the extreme northeastern corner of Pennsylvania, their easterly extension being close to the New York State line. This field falls into four natural subdivisions, the Northern, Middle Eastern, Middle Western, and Southern, the names of which are self-explanatory. While there have been frequent reports of the discovery of anthracite in other fields, the production of these, where they have been found workable, amounts to less than one per cent. of the output of the Pennsylvania field. It is now recognized that geological conditions have not been favorable to the formation of this most excellent domestic fuel in any other part of the country and the exhaustion of this field will mark the virtual end of our hard coal supplies.

THE EASTERN OR APPALACHIAN FIELD

This field has been aptly described as "the greatest storehouse of high-rank coal in the United States, if not in the world." The northernmost extension of this great coal reserve lies in Pennsylvania, just south of the New York State line, which it roughly parallels in its westerly extension over into Ohio, where it nearly touches Lake

Erie at Cleveland. From this northerly line it extends in a southwesterly direction, parallel to the Atlantic coast line, down into Alabama, a distance of eight hundred miles.

The field attains its maximum width of one hundred ninety miles at Pittsburgh, covering the eastern third of Ohio and nearly the whole of West Virginia. At Huntington, West Virginia, it begins to narrow in gradually and at Chattanooga, Tennessee, it is less than forty miles wide; but farther on in Alabama it terminates with a flourish in a roughly circular deposit one hundred miles in diameter.

This field stands preëminently at the head of the commercially valuable fields, not only in this country, but probably among the coal fields of the world, as well. It is true that British engineers have been reluctant to admit that even our best grades from this field excel their justly famed Admiralty coals in all the various particulars that go to make a perfect fuel, but they are at any rate not inferior, and in point of quantity we at least have a substantial advantage.

What may be properly termed the supercoals of this field are, by a peculiar geological freak involving increased pressures upon the coal measures, confined entirely to the eastern margin of the field. This increased pressure resulted in a marked increase in the carbon and an equally marked decrease in the volatile content of the coals in the affected areas, a condition that persists to varying degrees throughout the field. Thus, in the south, we have the popularly known New River and Pocahontas fields, marking the eastern limits of mining in McDowell, Wyoming, Raleigh, and Fayette counties of West Virginia. In the extreme northeastern corner of West Virginia lies the Upper Potomac field, the continuation of which across

the State line into Maryland is known as the Georges Creek or Elk Garden field, believed by many to contain the highest grade bituminous coal there is in this country. Across the border in Pennsylvania is another belt of this high-grade coal, still occupying the eastern fringe of the field and extending through Somerset, Cambria, Clearfield, and Clinton counties. The coals from this field are variously known as Miller Vein, Windber,[1] Quemahoning, etc., according to the district in which they originate.

Besides these supercoals, this field contains many special fuels which are almost equally famed for the particular use to which they are especially adapted. Thus we have the Connellsville region, already mentioned, which produces a peculiarly high-grade coke for metallurgical purposes. The special excellence of the Connellsville coke is recognized throughout the world and this field was an important if not a vital factor in the development of the great iron and steel industries of the Pittsburgh district. Between Pittsburgh and the Connellsville region lies the Youghiogheny field, from which the best gas-producing coals of the country are obtained.

In Ohio the most important field is the Number 8 or Belmont district, lying in a county of that same name and not far from the Pittsburgh district of Pennsylvania, which it resembles in some respects as regards quality of coal. The Hocking Valley field in Vinton, Athens, Hocking, and Perry counties enjoys the distinction of being the oldest and best developed of any of the Ohio fields. The coals of this State, while superior to those in many fields, are not of especially high grade. Mining costs have also been excessive and the operators have had to rely on the

[1] From Berwind, the Berwind White Coal Mining Company being one of the largest operators in this field.

geographical advantage of their closer proximity to the markets of the Middle West to make ends meet.

In addition to the supercoals of West Virginia already mentioned, this State has a wide spread of fuels of varying quality adaptable to every conceivable need. The Fairmont district, just south of Pennsylvania, covers a wide area in the northern part of the State and produces high-grade steam, gas, and coking coals. The Kanawha field adjoins the New River on the northwest in Kanawha, Boone, and Lincoln counties and produces a very high grade of gas coal from its Number 2 gas seam as well as high volatiles, splint, and cannel coal. The Pocahontas field, already mentioned, merges into the Clinch Valley to the southwest in Virginia, while its northwesterly extension up into Wayne County forms the Tug River, Thacker, and Kenova fields. The Tug River field produces the Pocahontas Number 4 coal, which is second only to the supercoal of the Pocahontas field itself, and also an exceptionally pure, soft coal from the Davy seam that is used principally for the manufacture of by-product coke. The Thacker field is noted chiefly for its high volatiles, splint, and cannel coals.

Passing over the State line into Virginia, we have the Clinch Valley field, already mentioned, the coals of which compare with those generally of West Virginia. There are other more or less important but isolated districts on the southern face of the Cumberland Mountains in Virginia, but the main operations of this section are to the north of this mountain range in Kentucky. This very extensive field, covering most of the coal-bearing area of southeastern Kentucky, is commonly referred to as the Harlan County field, though it, too, has subdivisions such as the Elkhorn field, a comparatively new district producing an exceptionally high-grade fuel. The coals of West-

ern Kentucky must not be confused with this eastern field as they are the southern extension of the Middle Western field to which they properly belong.

The coal-bearing measures of the Eastern field gradually narrow in passing through Kentucky, and in Tennessee reach their smallest width of something less than forty miles. Many of the coals in this field make an excellent coke and they are also harder and withstand storage and long transportation better than most fuels. While there are some extensive mining operations in the State, they are more or less isolated and there are no fields or districts such as obtain in Pennsylvania and West Virginia.

On the border between Tennessee and Alabama the coal measures have been badly eroded and the line of continuity almost broken until we reach central Alabama where the measures widen rapidly, covering more than half of the northwest corner of the State, and crowding over the border into Mississippi. To the northwest of Birmingham is the very extensive Warrior field, substantially the largest and most important in the State. Southwest of Birmingham are the Cahaba and Coosa Bay fields, lying parallel to the Warrior field and less than ten miles from it. A northeastern extension of the Warrior field reaching up into the corner of the State forms the Sand Mountain field; and the Lookout Mountain field lies parallel with it, and about five miles to the southwest. The Alabama coals rank well up to the front among the Eastern fuels, though they cannot compare with the special grades of Pennsylvania, West Virginia, and Maryland. The very excellent coking coal of the Warrior field has performed the same service to the Alabama iron and steel industry that the famous Connellsville coals have to Pittsburgh district.

This, briefly, is a description of the Eastern field. It is estimated to contain nine tenths of the high-grade coal in the country, the excellence of which has caused it to be an important, if not the dominant, factor in the wonderful industrial achievements of the last half century. Located in the high mountain regions of the Alleghanies, the coal is economically transported down to the Atlantic Seaboard for local use or for reshipment by water in the coastwise, bunker, or export trade, as will be discussed elsewhere.

MIDDLE WESTERN FIELD

This field spreads over the entire three quarters of lower Illinois, the western or southwestern quarter of Indiana, and across the Ohio River, where it forms the Western Kentucky field, already mentioned. The coals here belong to a distinctly different geological horizon from those in the Eastern field and are of a generally leaner quality. Their proximity to the great consuming centers of the Middle West, however, has given them a substantial advantage in these markets and the field as a whole ranks as second in importance among the coal fields of the country.

In Illinois the two most important subdivisions of this field in point of production are the Central Illinois and the Williamson and Franklin County fields, both in the extreme southern part of the State. The Du Quoin field forms the connecting link between these two fields, while the Big Muddy and the Saline County fields lie to the west and the southeast of the Williamson and Franklin County field, respectively. North of the Central Illinois field are the Pana, Virden, Springfield, and the Peoria and Fulton fields in the order named, and on the extreme northern boundary are the Rock Island, Northern, and

Wilmington fields, the latter being less than fifty miles from Chicago. The Grape Creek field is in the eastern part of the State, close to Indiana, and across the line in that State the coal area is so small that no important field subdivisions have been found necessary. The extension of the Middle Western field into the Western Kentucky field finds the coal there of somewhat better quality than elsewhere in the district.

To the north of the Middle Western field, in the State of Michigan, there is a comparatively large area of coal about equidistant from both the Eastern and the Middle Western fields, which takes its name from the State in which it is found. The coal of this area is very thin and irregular and of indifferent quality, making the mining operations exceedingly hazardous from an investment standpoint. The production of the entire field is no more than that of only a single moderately large company in the Eastern field and were it not for the advantageous geographical location of the field it would not have attained to even this mediocre prominence.

THE WESTERN FIELD

The northern extremity of this field terminates in a blunt spearhead eighty miles north of Des Moines, Iowa, from which it extends due south, across the northwestern corner of Missouri, through Eastern Kansas, and nearly across the State of Oklahoma. While the field is continuous throughout, custom has decreed that the southern extension in Oklahoma be classified as part of the Southwestern field and it will be so considered here.

The western limits of this field are purely a matter of speculation, as the coal measures dip under the later rocks to the west and disappear. These same measures have been found and identified in the Rocky Mountain regions

but the coal seams are entirely missing there. For purposes of estimation, it has been assumed that the coal ceases to be of commercial importance west of a north and south line through Lincoln, Nebraska. Working on this hypothesis, the field reaches its maximum spread at Lincoln, where it is two hundred and seventy-five miles wide, gradually narrowing to a width of sixty to seventy miles in Oklahoma and the known workable coals, within the limits of our present knowledge, are confined to the eastern two thirds of this area.

Mining is scattered throughout the area. The most important field is the Southern Kansas district, the other fields taking the names of the States in which they are located. The development of this field has been handicapped by the discovery of oil in Oklahoma, which has displaced the coal in many industries, but the mines have in the past been an important factor in the industrial advancement of this section. The coal of this field is a good grade of bituminous, comparable with that of Illinois and Indiana.

THE SOUTHWESTERN FIELD

As already noted, this field is merely an extension of the Western field into Oklahoma. In this State, however, the coal measures turn abruptly eastward, crossing the Arkansas line and terminating in a sharp point in the center of that State. This eastward extension has been subjected to heavy pressure, incident to the upturning of the Ozark Mountains, which has materially enhanced the value of these coals. The coal-bearing measures of this limited area, extending fifty miles into Oklahoma and one hundred miles into Arkansas, with a maximum width of seventy-five miles, contain some very high-grade fuels that are quite comparable with those of Pennsylvania

and West Virginia. The seams of this district are usually thin and expensive to mine, particularly in Oklahoma, and development has been much handicapped by troubles with labor unions, competition with fuel oil, etc., but in spite of these difficulties coal mining has persevered for a quarter of a century as one of the important industries of that section.

Between the Southwestern field and the Gulf of Mexico there is an extensive area of low-grade lignite coal, extending in a belt of varying width from the Mexican border at Laredo, through Texas, Louisiana, Arkansas, Mississippi, Tennessee, southeastern Missouri, and terminating at the juncture of the Ohio and Mississippi rivers less than twenty-five miles from the southern extremity of the Middle Western field. Attempts have been made to mine these lignites at points through this area but with indifferent results due to competition with the high-grade coals of the Warrior field on the east and the Southwestern field to the northwest; they will remain to form a supply of fuel for future generations who will perfect a means of briquetting it to improve its heating value when the existing supplies of high-grade coals have become exhausted.

THE ROCKY MOUNTAINS FIELDS

Under this general heading are grouped all the numerous fields between the Canadian and Mexican borders and lying, usually, on the eastern slope of the Rocky Mountains, from which they extend out varying distances into the Great Plains to the east. It is a region of widely scattered fields about which we still have much to learn and contains the greatest range in qualities of coal, from the lowest grade lignites to a fairly good grade of anthracite, of any field in the country.

The most westerly extension of this field consists of a

series of small isolated areas of sub-bituminous coals which occur in the Glacier National Park, in the vicinity of Missoula and Anaconda, Montana, and at other points. These coals have nowhere proved of commercial importance as yet. The Great Falls and Judith Basin fields, extending from the vicinity of Great Falls, Montana, about one hundred and fifty miles east, contain a very good grade of bituminous coal, though with a rather extraordinarily high ash content; this field has been an important source of supply for the Northwest. North of this is the Assiniboine field, a sub-bituminous coal, covering a broad territory but not mined to any extent. To the southwest is the Bull Mountain or Round-up field which has been developed quite extensively in the past decade or more and produces a very good grade of sub-bituminous coal.

East of the fields just described is an enormous area of coal-bearing measures covering the western half of North Dakota, the eastern quarter of Montana, and extending in a broad belt one hundred miles wide down into the east center of Wyoming. The entire northeastern portion of this field is known as the Fort Union region and carries a very low grade of lignite which is, however, extensively mined locally. Beginning at a line running slightly east of north through Miles City, Montana, this coal gradually changes in character, merging into a distinctly sub-bituminous grade within a distance of twenty-five miles and continues as such down into Wyoming, where it is known as the Powder River region. This sub-bituminous coal is mined to some extent at Miles City, and at Sheridan and Cambria, Wyoming, it is being produced on a comparatively large scale. East of the Powder River field are the Big Horn Basin and Wind River districts, the former producing a fair grade of bituminous coal in the Bear Creek-

Red Lodge field, which has been an important source of supply for the State of Montana.

Almost the whole of the southwestern quarter of Wyoming is covered with another enormous coal field known as the Green River region. Some of the coals in this district are among the best in the Rocky Mountains and they have been extensively developed on a large scale, and over a long period. The best known fields of this district are the Kemmerer, the Rock Springs, and Hanna. South of this region is another exceedingly large coal area called the Uinta region, which is almost as extensive as the Green River region, though it does not appear to have as many seams. This field has a very wide range of coals from lignite up to, if not quite the equal of, the best grades in the Green River region. The principal mining fields in this district are the Blacktail, Castlegate, and Emery on the western border and the Crested Butte field on the east.

Denver, Colorado, is surrounded by a field which takes its name after that city and which, together with some outlying fields in the immediate vicinity, such as the North and South Park and Canon City fields, have been developed on a moderate scale. Farther south, on the border between New Mexico and Colorado, are the Trinidad and Raton fields which form the most extensive deposits of coking coal there are in the West. These fields have been the most important source of supply the Western smelting interests have been able to find and have consequently been opened up on quite an elaborate scale. West of the Trinidad and Raton fields and south of the Uinta field is another fairly large coal area known as the San Juan River region. The southern portion of this field contains sub-bituminous coal and in the northern part is a very good grade of bituminous, the State line between Colorado and New Mexico being the approximate line of demarca-

tion between the two grades. This field has been developed on a considerable scale, the principal operations being at Durango where a very good grade of coke is also produced.

PACIFIC COAST FIELDS

The important coal fields of the Pacific Coast region are confined to the State of Washington. Coal has been discovered in both California and Oregon and some attempts have been made to develop the fields in the latter State but with only indifferent success. The quality of the coal in both of these States is very inferior and it is doubtful if they prove a factor in the Pacific Coast fuel industry for long years to come.

Of the Washington coals, the Roslyn field is the only one east of the Cascade Mountains. It contains a very fair grade of bituminous coal which has been mined quite extensively by the Northern Pacific Railroad. The Kings County field in the immediate vicinity of Seattle, on the western slope of the Cascade Mountains, contains good grades of bituminous coal also and has many large operations; this field has numerous subdivisions such as the Green Mountain, Cedar Mountain, Newcastle, etc. The Pierce County field, south of Kings County and close to Tacoma, does not contain a very large area of workable coal but it is credited with the best grade of fuel in the State and has been the scene of active mining. West and southwest of the Pierce County field are the Centralia and Cowlitzs, the coals of which are much inferior, being almost lignitic in character and there has never been any extensive mining in these districts. The Whatcom and Skagit fields in the northern part of the State, near the coast, contain a wide range of coals varying from low-grade bituminous to a very fair grade of anthracite. Mining operations are not on an extensive scale here.

CHAPTER IV

Our Coal Reserves

One of the most pressing economic problems of modern times is the determination of the prospective life of our coal reserves. The exhaustion of our fuel supplies would be a matter of the gravest concern and presents possibilities that are not pleasant to contemplate; it would mean not only the cessation of industrial manufacturing, fabrics, shoes, household necessities, etc., but the absence of any mode of transporting these, as well as food, to the points of consumption. Under these conditions it would be impossible to sustain life in cities and towns, so these would disappear, except, perhaps, in the smallest communities or villages. Man would, perforce, revert to type, and in the course of time we could picture him herding sheep or cattle by day and retiring at night in a miserable hut by the light of a tallow candle, whole families sleeping together for warmth. Or perhaps some favored country (China, for instance, with her enormous undeveloped fuel supplies) would have grown in power, in the face of the general world decadence, so that her navies would be collecting the treasures of the modern countries, for which she would give in return a few pounds of coal.

Such would be the picture of a Fuelless Age, but it is not one that we need contemplate with any degree of anxiety at the present time. The areas of known and proved coal in this country are adequate for centuries to come, even after making due allowance for increases in

our present rate of consumption, and we shall, in the meantime, discover as much more that is not now known, or is of indeterminate extent. During this time, science will also develop new sources of power, of which we know nothing at present, or devise new methods of realizing greater efficiency from coal. As an example, it is a well-established fact that the most modern type of boiler and steam engine only produces eight per cent. of the real efficiency in the coal at the end of the piston; on this basis the heating furnace of the average householder probably realizes about one half of one per cent. of the true efficiency in the coal.

There are so many unknown factors to be approximated in preparing an estimate of the prospective life of our coal reserves that the final result can, at best, be only a vague hazard. There is, first, the lack of complete knowledge as to the extent of our coal fields and the thickness and continuity of the seams therein. A striking example of this difficulty is the question of where the western limits of the Western coal field lie, as mentioned on page 22. We see these rich coal-bearing measures in Iowa, Missouri, and Oklahoma disappear under the more recent deposits in the western part of those States to reappear completely barren in the Rocky Mountains, some five hundred miles distant. Thus we have an area of not less than two hundred and fifty thousand square miles of possible coal-bearing measures, about which we know nothing. This territory is not recognized as containing coal in the estimates prepared by the U. S. Geological Survey, which will be quoted farther on, but if it should prove to be coal-bearing, there would be some billions of tons in this field alone.

Other questions about which we are in doubt are: The minimum thickness of coal that can be economically

mined, which depends on the price obtained for it, something no one can anticipate several centuries ahead; the maximum depth to which we can mine, which again depends somewhat on the price obtained for the coal as well as on the invention of proper mechanical devices for operating at greater depths, etc.

It is of interest here to review the various efforts of Great Britain in her attempts to arrive at some estimate of the probable life of her coal reserves. The coal fields in that country are very limited as compared with our own; they have also been much more extensively mined, and consequently better proved up, so that there is comparatively reliable data available for preparing an estimate of her resources. Witness, then, the estimates prepared by different commissions that have studied this question.

While no official estimate of the situation was made at the time, we find the British miners already contemplating the possible end of their industry as early as 1710, because of their inability to cope with the mine water at the depths they had then reached. The appliances then in use had reached the limit of their capacity and many of the pits had been drowned out and abandoned when the problem was solved by the invention of the atmospheric engine in that year. This is an elementary example of how intimately the development of the coal industry is tied into the advancement in mechanical lines.

The first authoritative report on the British coal reserves was made by Professor Hull in 1860, who estimated the supply at that time as amounting to eighty billion tons. His estimate included seams of two feet and more in thickness, up to depths not to exceed four thousand feet, but he did not include seams that were overspread with formations later than the Carboniferous period.

In 1871 a Royal Commission was appointed to investi-

gate the question. They issued a preliminary report in that year, based on the same assumptions as Professor Hull's, except that they included seams of one foot or more in thickness, in which they estimated the total reserves of proved coal at ninety billion tons. A second report of this commission, issued in 1905, placed the total reserves of proved coal at one hundred and one billion tons, and estimated there were an additional forty billion tons of unproved coals within the practical limits of mining, or a total of one hundred and forty-one billion tons in all. In 1912 Doctor A. Strahan of the British Geological Survey compiled an estimate in which he placed the total reserves at one hundred and seventy-nine billion tons, and this was followed by another estimate by Professor H. S. Jevons in 1915, of one hundred and ninety-seven billion tons.

Thus we see the fallacy of compiling any reliable figures as to coal reserves. After half a century of progressively intensive mining, the British coal reserves are estimated at more than twice what they were at the beginning. For reasons already cited, there are substantially greater difficulties in the way of preparing an estimate of our own future supplies, but the matter is sufficiently pertinent to justify an examination of the best knowledge available on the subject, for which we are indebted to a very exhaustive compilation of the U. S. Geological Survey.[1]

The Survey estimates our total remaining reserves of all grades of coal in 1914 at 3,539 billion tons. This estimate is predicated upon a maximum depth of mining of three thousand feet and if this be extended to six thousand feet there will be an additional 666 billion tons available.

[1] "The Coal Fields of the United States." Professional Paper 100–A, U. S. Geological Survey, Washington, D.C., 1917.

While the three-thousand-foot limit is substantially beyond the present depth of coal mines in this country, it is on the whole a very conservative maximum. The coal mines of Europe already extend well beyond that depth and our metal mines in this country are being worked to depths of 5,500 feet. It is evident that the mechanical problem of mining at depths of six thousand feet has been solved at any rate, and it is therefore proper to include all coal within this horizon. Costs of mining will, of course, be substantially greater and it will be an exceedingly difficult problem to maintain production on a large scale, but we must remember that when the time arrives we will be dealing with an emergency situation to which these matters will be but supplementary details.

In fixing the minimum thickness of seam that will be mined, the Survey has very painstakingly adopted a sliding scale for the various grades of coal, on the assumption that it will be possible to mine to greater depths for the better grade fuels. Thus it has taken fourteen inches as the minimum thickness for the best grades of coal, two feet for sub-bituminous coal, and three feet for lignite. It does not seem to the author that this is a logical hypothesis to work upon, for the reason that we are again overlooking the fact that when the time comes that these coals will be required, we will be facing an emergency situation in which the matter of quality will be a mere detail. And further, it makes it difficult to compare our resources with those of other countries, England, for instance, where a uniform minimum of one foot in thickness has been adopted in computing her reserves. This is a matter of some importance, as in the last analysis, what we are largely concerned about is the question of whether our reserves will be exhausted before those of the other great industrial countries.

A study of the geographical distribution of our coal reserves, as revealed in Table 1 in the appendix, discloses the further interesting fact that the declining days of the coal industry will find it confined entirely to the Western States. It is a fact little appreciated that, of our total original reserve of 4,220 billion tons, only 1,103 billion tons lie east of the Mississippi River and that 14 billion tons of this had been exhausted at the end of 1914. In the fields west of the Mississippi there are 3,118 billion tons, of which scarcely half a billion had been mined at the end of 1914.

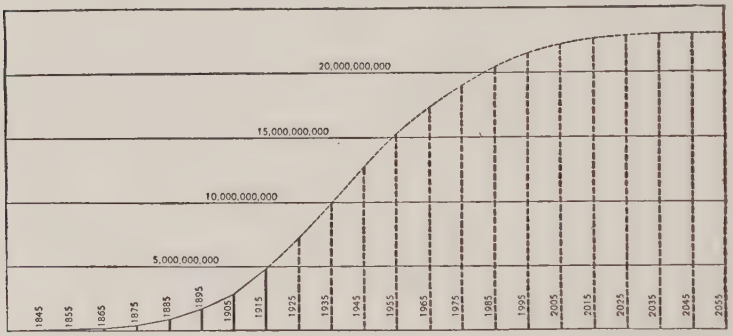
In an effort to visualize the enormous volume of our coal reserves the Survey makes the interesting computation that, assembled in a square block, this would measure 18 miles on all sides. After allowing for 50 per cent. waste in mining, the total extraction since the beginning of mining would form a similar block a quarter of a mile on each side. The total exhaustion to 1914 has been four tenths of one per cent. of our total reserves.

PROBABLE LIFE OF THE COAL RESERVES

If we may assume the preceding figures as to our coal reserves to be approximately correct, it then becomes possible to compute the probable length of time these may be expected to last. But here again we encounter a vital unknown quantity in the rate of increase in the production. This rate has progressed at such a speed as to give the proponents of the early exhaustion theory very excellent grounds for their fears. A continuation of this rate would place the end of the coal reserves within our range of vision but the past few years have shown a most encouraging reaction in the face of an increased industrial activity, which would seem to indicate that we have entered into a period of decline.

A most ingenious solution of this problem was worked out by E. W. Parker[1] in regard to which the U. S. Geological Survey, in "The Coal Fields of the United States" already mentioned, has the following to say:

In 1908 Parker [2] attempted to extend the curve of production to what he conceived might be the possible maximum that would ever be reached in this country. His curve, with slight modification to fit recently acquired data, is shown in Figure 1. The past and the estimated



U. S. Geolo. Survey.

FIG. 1. Curve showing probable rate of increase in coal production to the anticipated maximum output in the year 2055.

future production were grouped by decades, beginning with 1835 and extending to the year 2055, when, according to his calculations, the maximum production of 23,000,000,000 short tons would be reached. As the quantity of coal mined in the decade ending with 1914 was 4,779,820,431 short tons, the maximum, according to Parker's figures, would be roughly five times the present production. After the maximum had been reached the

[1] E. W. Parker was statistician of the U. S. Geological Survey for a long term of years, during which time he had occasion to study this question in some detail.

[2] Parker, E. W., "Past and future coal production in the United States: Mines and Minerals", 1908, pp. 462–465.

production, owing to increased cost of mine haulage, of hoisting from deeper shafts, and of working thinner beds, would gradually decrease, but the decrease would probably be much less rapid than the increase up to the maximum.

The figures showing the production since 1908 prove that Parker's curve is too flat, for his estimate of the production in the decade ending in 1915 (4,528,000,000 tons [1]) is nearly equaled by the production of the nine years ending with 1914, which is 4,387,097,796 tons. Thus it seems that his estimated maximum production is too small or that the maximum will be reached before the year 2055. The estimate is probably too small and the maximum production will therefore probably be greater than 23,000,000,000 tons in a decade.

Although by every reasonable estimate the ultimate exhaustion of the coal reserves of the United States appears to be an event so far in the future that it need concern this generation but slightly, the fact must be remembered that the bulk of the coal being mined to-day is the best in the country and that before long, perhaps within 50 years, much of the high-rank coal will be exhausted.

While it thus appears, from the best knowledge we have up to the present time, that sometime about the fortieth century will see the exhaustion of our coal supplies, the author wishes to call attention again to the many hypothetical conditions on which this is based. There is only one condition that can advance this time to any degree (an unexpected increase in our rate of exhaustion) while there are many others by which it can be materially extended, — the discovery of new coal measures and ex-

[1] The production for the decade ending in 1915 was 4,918,717,283 tons. The total production for the country to the end of the year 1921 according to the U. S. Geological Survey was 14,527,629,946 short tons.

tensions of those already known, mining seams thinner and to greater depths than is now considered within the limits of possibility, etc. We have also the latent potentiality of uncovering a more economical method of using coal whereby the efficiency will be increased tenfold. Important advances are being made along this line with the gas engine and the author will be disappointed if he does not live to see the day when he will be able to run his car for a month on a couple of shovelfuls of coal.

THE WORLD'S COAL RESERVES

Reference to Table 2 in the appendix, giving the estimated coal reserves of the leading countries of the world, discloses the interesting fact that the United States stands very substantially in the lead with fifty-one per cent. of all the coal in the world. Canada has the next largest reserves and she is tied to us by economic bonds that make it entirely reasonable to include her supplies in with our own. China is rated as third, though little is known about her reserves and some engineers who are familiar with the geology of China think they have been exaggerated. Germany and Great Britain are fourth and fifth respectively.

But while our country is thus richly endowed as regards her future supplies, she is equally profligate in her expenditure of these bountiful resources, as will be seen by reference to Tables 4 and 5. It will be observed in Table 5 that this country has been supplying a constantly increasing percentage of the world's coal supply up to the last year of the war in 1918, since which time the other countries have been able to resume production on a larger scale and have partially retrieved their lost ground. If we may be permitted to resort to banking phraseology for a moment, the rate of increase, in terms of compound interest, for the leading countries is: United States six per cent.;

Germany four per cent.; Great Britain two per cent. This pyramiding in the rate of exhaustion of our reserves to fifty per cent. more than Germany and three times that of Great Britain is a matter of real concern to the economist.

In Table 6 the world's reserves are given according to continents, in which it will be observed that the American continent stands preëminently in the lead with four times the amount of coal held by its nearest competitor, Asia, and nearly seven times the European reserves. Table 3 gives a comparison of the coal reserves and populations of the leading countries, in which it will also be noted that we have a substantial advantage; Germany, our nearest rival in this respect, has only about one sixth the amount of coal per head of population as this country, and Great Britain one ninth.

In Table 5 we give the latest returns for the production in the five chief coal-producing countries of the world, in Table 7 the world's production by countries for the years of 1920, 1921, and 1922, and in Table 8 the United States production since the beginning of mining. The reader is particularly cautioned in using these figures to distinguish between the short or net ton (2,000 pounds), the long ton (2,240 pounds), and the metric ton (2,204.62 pounds). Both the long and short ton are used in this country, though the former is confined largely to anthracite coal in Pennsylvania and to bunker business. The metric ton is used almost exclusively abroad.

PART TWO

MINING METHODS

CHAPTER I

Early Methods of Mining

Coal mining had been carried on abroad for several hundred years before America was discovered and nearly four centuries elapsed between that time and the beginning of operations here on any important scale. The Europeans had by this time passed through the initial stages in the development of the present-day mining methods. When mining was started on a comprehensive scale here, the methods and customs were imported from overseas, so that we are obliged to go back to the early days of the industry abroad for the first methods employed in extracting coal.

THE FIRST MINING

The records of the first mining in England are not of a very savory character, as viewed in the humanitarian lights of the twentieth century. We find, for instance, where three hundred and sixty miners were impressed for service in 1296, and in 1373 the Bishop of Hatfield designated certain commissioners to seize workmen and coal bearers, wherever they could be found, with full power to imprison and punish them, should they prove rebellious. In 1526 Henry VIII considered a proposal to levy men for the coal mines and in 1580 Queen Elizabeth granted powers to impress workmen, wagons, and horses.

Even as late as the first half of the nineteenth century we find rather appalling labor conditions existing in the British mining industry. Labor was hired on a yearly basis, under conditions that amounted to virtual slavery, at twenty cents per day for able-bodied men and six cents for women. Boys and girls worked sixteen to eighteen hours a day under the most unsanitary and dangerous conditions, not seeing daylight from one week's end to the next.

The first mining of coal was confined to what we would now term quarrying methods, the coal being broken off from along the outcrops at the surface. As the supplies of this became exhausted the seams were followed under ground, as much of the surface cover as possible being taken off first. This first real mining probably took the form of a simple gouge in the hillside, such as may be seen at some country banks to-day, and may have included some elementary form of timbering to make it possible to follow the seam in a short distance.

Even under the most favorable conditions the supplies obtained by these methods could not have sufficed for long with the increasing consumption, and it soon became necessary for the actual underground mining as we know it to-day to be started. So we find the surface holes being timbered up and the seam followed in by means of tunnels, called "day holes" or "day levels." The sinking of shallow shafts through surface material to the coal also appears to have been initiated at about this same time. These were usually called "bell pits" or "beehive pits", taking their name, no doubt, from the method of working which consisted of simply gouging out the coal around the bottom of the shaft as long as the roof would stand and then abandoning the shaft. As the more shallow seams were exhausted and it became

necessary to sink the shafts to considerable depths the labor involved in this preliminary work became prohibitive in view of the small amount of coal recovered so that the practice of tunneling from the shaft bottom was started.

With the advent of these tunnels, both from the shaft bottom and entering from the hillside, it became necessary to provide for a means of transporting the coal from the working face where it was mined to the outside. This

Mines and Minerals.

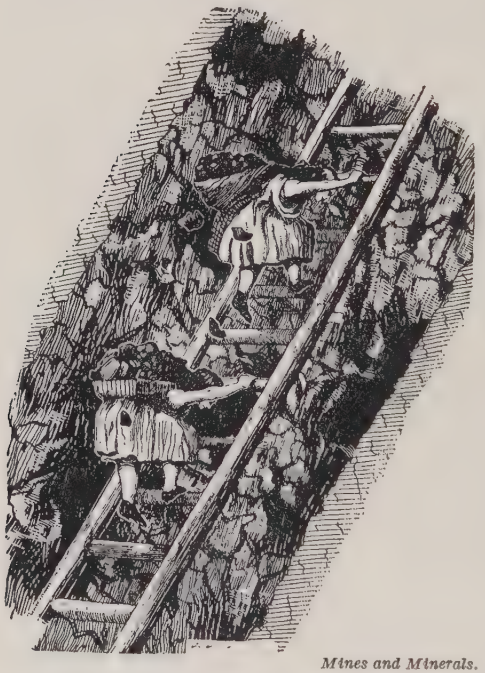
FIG. 3. Women drawing coal-laden "tubs" by a chain attached to the waist.

work was not considered of sufficient importance to require able-bodied men, so women, boys, and girls were employed for this purpose. The coal was first loaded in baskets, called "corves" and carried out on the back as shown in the frontispiece. Later these corves were dragged out on sleds or the two combined into what was called a "tub" which was drawn by women as shown in Figure 3.

Up to the middle of the fourteenth century, and in some instances considerably beyond that, coal was carried from the shafts by women as shown in Figure 4. About this time, however, the man-operated windlass came into use for hoisting the coal from the shafts, a contem-

porary writer of early times describing the operation as follows:

"They used not engines for lifting up the coals out of the pitt, but made theire entrance slope, soe as the people carried the coals on theire backes along stayers, which they called landwayes; whereas nowe they sinke theire pittes downe right foure square, about 6 or 7 foote square, and with a wyndles turned by foure men, they drawe up the coles a barrel full at once by a rope." Pits at that time were being sunk to depths of seventy to one hundred and twenty feet.



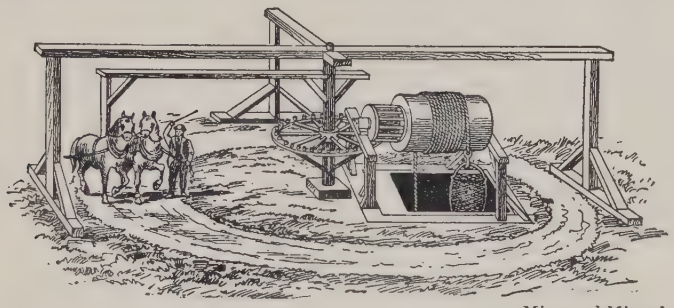
Mines and Minerals.

FIG. 4. Before the days of the windlass women carried the coal from the shafts in this manner.

Considerable water was being encountered at these depths and there is mention of some description of a pump being installed in 1486, though most of the mines were drained by long adits driven in the rock. Coal was still being transported underground on the backs of women who were called bearers. The reader should note here the advancement, if such it may be termed, made up to the discovery of America.

SIXTEENTH AND SEVENTEENTH CENTURIES

The sixteenth century appears to have witnessed only one important achievement in the fuel industry, — the granting of a patent for the manufacture of coke; but the seventeenth century brought forth many new methods. Shafts were now commonly one hundred and twenty to one hundred and eighty feet deep with some up to three hundred and four hundred feet deep. These greater depths had only been attained through radical improve-



Mines and Minerals.

FIG. 5. The cog-and-rung gin balanced hoist used in the seventeenth century for hoisting coal from vertical shafts by means of horses.

ments in mechanical equipment and we find the man-operated windlass has given way to a cog-and-rung gin [1] driven by horse power, as shown in Figure 5. The method of operating this hoist is evident from an examination of the illustration but it is of interest to note that the principle of the balanced hoist, wherein the weight of the descending empty bucket is utilized to assist in raising the load, was developed at this early date; this principle finds wide application in shaft hoisting to-day. The shafts were usually six feet square, though sometimes they were only three or four feet.

[1] Gin is an early abbreviation for engine.

The problem of draining the mines at these increased depths was most acute. It had been necessary to lengthen the adits driven through rock up to several miles in some instances; these were frequently made only eighteen inches wide for purposes of economy and the hardships and expense of these operations without the power drills and facilities for blasting are inconceivable in these days. Partial relief from this trouble was obtained, however, about 1670, with the introduction of the chain bucket pump from Germany, where it appears to have been used in the iron mines since about 1550. A typical installation of this character, driven by water power, is shown in Figure 6, and it will be observed that it works on the principle of the present bucket elevator. Water power was used wherever available, being conducted to the shaft mouth by flumes. Where none was to be had resort was made to horse power, the apparatus being connected up by gears in much the same manner as the cog-and-gin hoist shown

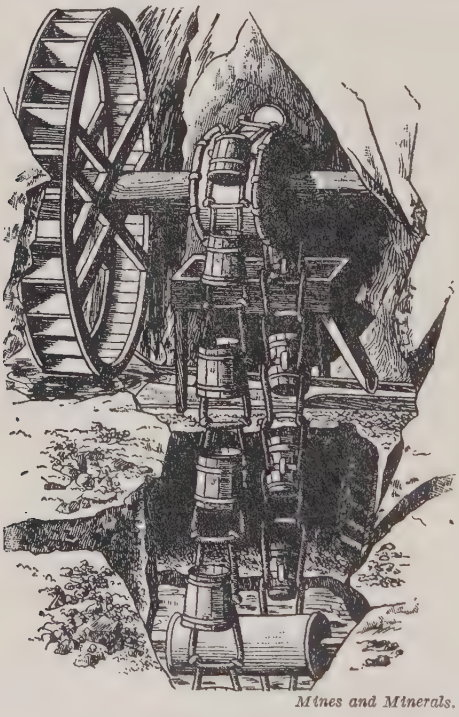


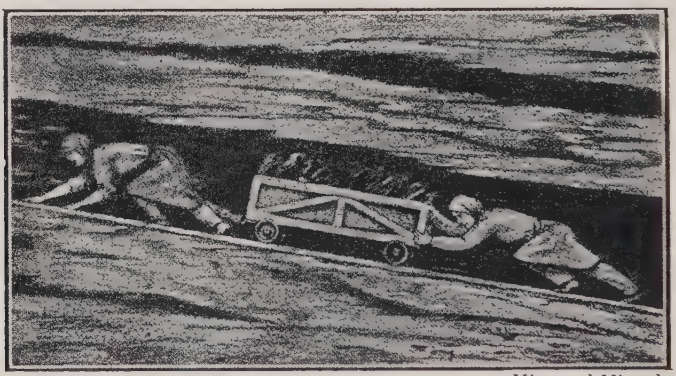
FIG. 6. The first type of mechanical drainage. Bucket elevator driven by a water wheel.

in Figure 5. This device was said to have been worked successfully in handling both coal and water up to depths of 240 feet. For greater depths than this two or more of them would be installed at different levels and the water hoisted in stages.

The seventeenth century also brought with it the first evidence we have of mine disasters resulting from explosions and floods. The initial fatality from the deadly fire damp, which was destined to bring sorrow to the mining communities down to the present time, occurred in 1621, and by 1675 we find records of explosions so violent that men were blown out of the shaft mouth. The safety lamp was as yet unknown and it seems incredible that gaseous mines of the extent they had reached by this time could have been worked at all without them. There was no way of determining whether the gas was present or not except by testing with a naked light and the men selected for this precarious duty must indeed have been of a courageous type. In the year 1658 we find a record of a disaster of some proportions caused by breaking into some old workings which were standing full of water.

Boring for coal, in order to prove the ground before initiating expensive development work, was started in 1610. But the most important development of this century was the introduction of wagons and tramroads for transporting coal underground about 1650, though these too appear to have been used in Germany for some time prior to that. An early type of mine wagon and method of operating is shown in Figure 7. Two women called "putters" were usually employed in drawing them, the one in front pulling the wagon by means of a chain attached to her belt and passing back between her legs to the car, and the other pushing from behind. The tracks were first laid without any crossties and consisted

of simple timber pieces laid end to end; later they were surfaced with a thin strip of hard wood to prolong their life and still later the rails were surfaced with thin sheets of iron. The wagons were very crude, being equipped with wooden wheels more in the nature of rollers. Nevertheless the whole represented a distinct advance over the previous methods of handling the coal underground and



Mines and Minerals.

FIG. 7. The first mine car and how it was handled by the women "putters."

the joy with which this innovation was received by the workers was set forth in the following verse:

God bliss the man wi' peace and plenty
That furst invented metal plates;
Draw out his years to five times twenty,
Then slide him through the heevenly gates.
(Thomas Wilson)

The operators were now facing economic conditions that forced them to devise more comprehensive methods of mining. The most important of these was the large initial investment required in sinking the shafts to the comparatively great depths they were then reaching and the necessity for recovering a greater tonnage from these

shafts, in order to reduce the investment cost per ton of coal extracted. The improved means of transporting coal underground made it possible to materially extend the scope of operations from the shaft bottom and with this came the introduction of the room-and-pillar system of mining. This method has come down to the present day as the fundamental system about which all methods of mining coal have been built, with the single exception of the long-wall method. These methods of working will be discussed in another part of this section.

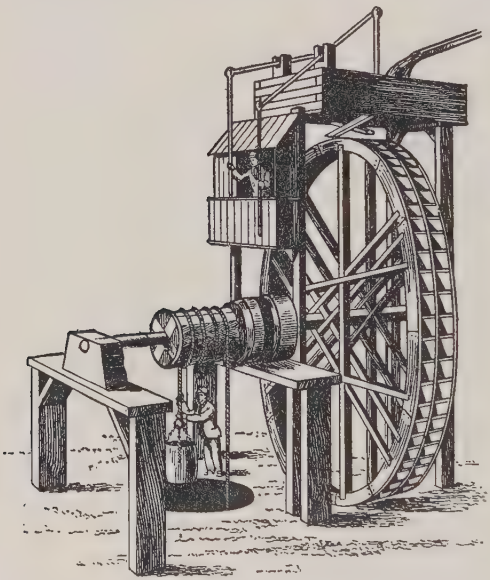
The larger extent of the mines, and the increasing danger from explosive gases had also caused the miners of the seventeenth century to begin consideration of the problem of ventilating the mines and we find the first records of the use of the fire lamp. This method, which is still used to some extent in very small mines, provides a draft or circulation through the mine by means of a chimney in which the air is heated; the hoisting shaft is ordinarily divided into two compartments for this purpose, one being designated the downcast and the other having the fire at the bottom, the upcast.

EIGHTEENTH CENTURY

The dawn of the eighteenth century, 1719, saw the first appearance of gunpowder for use in blasting operations, though this also appears to have been used in Germany for a full hundred years prior to this time. The use of this was confined entirely to shaft-sinking operations through the hard rocks for another hundred years, and was not applied to the blasting of coal until the early part of the nineteenth century.

The eighteenth century also witnessed a notable series of improvements in the methods of hoisting. In 1777 we find the principle of the water wheel, which had been used

as a bucket elevator in the seventeenth century, being adopted for hoisting as shown in Figure 8. It will be noted that the single wheel has been replaced by a double wheel, the buckets in which are set in opposite directions so that the wheel may be driven either way by diverting the water to the different sets of buckets. This proved an important advance over the horse-operated gin, both in economy of operation and speed of hoisting. A plant installed at this time was credited with hoisting 650 pounds from a depth of 492 feet in two minutes.



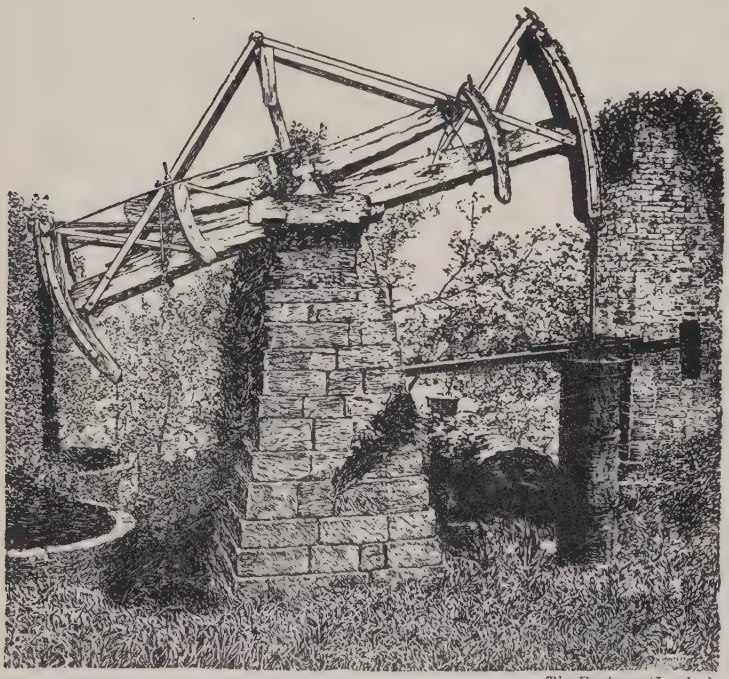
Mines and Minerals.

FIG. 8. Improved type of reversible water wheel used for hoisting coal in the eighteenth century.

Where plenty of water was available, and the mine provided with natural drainage by adits, another ingenious adaptation of the balanced hoist came into use at this time. The principle of the balanced hoist has already been mentioned and this application of it provided for a tub holding sufficient water to slightly more than counterbalance the weight of the coal to be raised. The tub was filled at the surface, thus raising the coal to the top, and the water dumped out when the tub reached the bottom, the two tubs being so weighted that the one holding the

water automatically returned to the surface when both were empty.

But of far greater importance than either of these was the development of power-operated engines of different kinds. The first of these made its appearence in 1712



The Engineer (London).

FIG. 9. The first type of power-driven engine used for pumping service.

and was known as the atmospheric engine. An engine of this type is shown in Figure 9 as it stands to-day at an abandoned colliery in England, though having been out of use for more than a century. For the first fifty years or so these engines were used exclusively for pumping service and were of great assistance in this work; in fact, their discovery made it possible to reopen a number of

collieries that had already been abandoned because there had been no practical method of draining them.

The first application of the engine to hoisting coal was made in 1758. It progressed through several stages, and in 1782 Watt succeeded in developing an engine wherein the power was applied to both sides of the piston alternately, thus providing a continuous cycle to its operation. An engine of this type was installed in 1784 and remained in operation until 1863.

These improved hoisting facilities do not appear to have had any influence on increasing the depths of the shafts which remained at a maximum of four hundred feet as in the preceding century. It is probable that very considerable coal territories became available at this depth, as compared with the limited consumption of the times, and the relatively crude mechanical facilities for working at the greater depths would naturally tend to limit the mining activities to the shallower zones.

The increased mining at these lower levels, however, resulted in many additional explosions which became more violent in character as the mines grew larger. A contrivance called the steel mill had been invented for use in lighting the gaseous workings but it proved almost as dangerous as the open light, and even more so when it was accepted as safe and used indiscriminately in workings known to be dangerous. This device was of appalling crudity as measured by existing standards, consisting of a steel disk revolved at a high rate of speed by means of a handle, the periphery of the disk being in contact with a piece of flint which threw off a stream of sparks; thus one man or a boy turned the crank of the wheel while another mined the coal by the meager light thus evolved. The firing of large bodies of standing gas in order to dispose of it was still practiced, this having also increased in

danger with the larger size of the workings; those engaged in this precarious work had evolved numerous ingenious methods of reducing the hazards, such as pulling a lighted candle into the danger zone by means of a string passing around a pulley, while they barricaded themselves in some safe place as near the shaft bottom as possible.

Another important achievement of this century was the adoption of cast-iron wheels for the mine wagons, and ponies to draw these, as well as the iron-plate facing for the wooden rails as already noted, the iron rail itself coming into some use on the surface where cars were handled around the shaft top. The systems of mining had been further improved with the introduction of the long-wall method and we find the operators giving more consideration to the matter of leaving larger pillars with a view to working over the second time. Cast-iron tubing for lining the shafts had also come into use where shafts were sunk through specially bad ground and we find mention of the first use of shaft guides to make it possible to hoist at greater speed and eliminate accidents from bumping the sides of the shaft.

This was the status of the European practice at about the time we were beginning to contemplate the possibilities of any appreciable production in this country. The British miners were already working at depths of four hundred feet, whereas we had scarcely begun to scratch the outcrops; hoisting and drainage problems far in advance of anything we would require for the next half century had been solved and the best practice in mining the coal had been predetermined for us. Great Britain was still setting the pace for us through the first half of the nineteenth century and it is necessary for us to continue our survey of the progress there in following through with the history of the industry as a whole.

NINETEENTH CENTURY

The nineteenth century will go down in history as the real beginning of the Coal Age. The progress in this century, in terms of the results achieved in output, methods of mining, mechanical improvement, etc., relegates that of the preceding centuries to the accomplishments of a merely preparatory stage. The close of the century finds us working at maximum depths and with adequate facilities for going still farther, our mechanical appliances approaching perfection, problems dealing with explosions under some control, and with an enormous production that even our successors of a century hence are bound to respect, unless, indeed, our supplies of coal are to be exhausted much sooner than we anticipate. Certain refinements and improvements in the existing practice are to be anticipated in the course of time, but the succeeding generations will be engaged more in picking up and perfecting the loose ends left over from the sweeping changes of the nineteenth century and there will never be a recurrence of the revolutionary developments of that time. The history of this century is, therefore, of peculiar interest.

One of the early and most important improvements of this period was the invention of the safety lamp. The opening years of the century had witnessed a series of appalling explosions which made it apparent that mining could not survive for long without a solution to this problem. The services of a noted scientist of the times, Sir Humphry Davy, were enlisted and in 1815 he introduced the Davy lamp, the principle of which, though with some variations, is applied to all oil-burning safety lamps to-day. This principle rests on a very elementary phenomenon which can be easily demonstrated by holding

a knife blade in the flame of a match; it will be observed that the cool metal repels the flame, leaving a perceptible interval between the blade and the flame itself. Sir Davy conceived the idea of confining the flame of the miner's lamp with a multiple of such cool surfaces and for this purpose used a cylinder of wire gauze, sealed at the top and fitting securely around the lamp at the bottom as shown in Figure 25. A very fair degree of light passed through the gauze, adequate ventilation was provided, and the flame of any gas lighted by the lamp would not pass through the gauze and ignite that on the outside. Like all innovations, the adoption of the lamp was slow and it was some fifteen or twenty years later before all the gaseous mines were equipped with these lamps.

The recurrence of still more violent explosions during this time was due in a large measure to the continued use of the steel mill, which many of the older miners were reluctant to give up, and also to the method of furnace ventilation, the mine gases sometimes working back to these and being ignited there. Before the advent of the safety lamp the problem of removing the gas had become so serious that special entries were sometimes driven for the sole purpose of draining it off, in much the same way as the rock adits were used for drainage in the preceding centuries. More complex methods of ventilating were also being introduced, such as splitting the air into two or more parts for different sections of the mine and in 1837 we find mechanical ventilators being experimented with, and a fan with a capacity of 13,500 cubic feet of air per minute was put in operation in 1844.

Improved methods of hoisting and drainage had given a great impetus to shaft sinking, and the maximum depth of four hundred feet was extended to one thousand six hundred feet in the first quarter of the new century,

while the previous maximum size of seven feet square was increased to as much as fifteen feet in diameter, the circular form of shaft having replaced the square. The construction of more powerful hoisting engines and the application of shaft guides had effected radical changes in the methods of hoisting and we find the corf and basket replaced with iron cages on which the wagons, loaded with coal, were hoisted to the surface and dumped, even the double-deck cage handling two wagons at a time having come into use by 1835.

Cast-iron rails were adopted both above and below ground in the opening years of the nineteenth century and by 1820 the wrought-iron rail was beginning to come into use. The best general systems of mining had already been devised, but we find some refinements being added, such as the use of the panel system of working.

But the greatest improvements were in the mechanical field. The hoisting engine was being slowly perfected and in 1850, the double cylinder hoist was introduced, stabilizing the heretofore eccentric action of the engine without the use of the cumbersome flywheel and adding greatly to the power, speed, and control of the mine hoist. Ropes of iron wire had supplanted the hemp ropes previous to this and were generally adopted for hoisting, and with the further improvement in the steam engine they also came into use for haulage purposes as well. Stephenson's invention of the locomotive in 1828 was taken up and applied to mine haulage almost as rapidly as it was to railroad use.

Social conditions of the mine workers came in for a very thorough investigation by the British government in the second quarter of the century. Women, boys, and girls were still employed underground up to this time, working twelve to fourteen hours a day under the foulest conditions

imaginable and seeing daylight on Sundays only. A Royal Commission was appointed to investigate the working conditions of the miners and the publication of their report resulted in a radical change in the employment conditions by the middle of the century.

It is interesting to compare this stage in Great Britain with the very elementary methods of working that were being applied to the development of the coal mines in America at this time. In the Georges Creek field of Maryland, one of the earliest bituminous regions to be actively developed, we find quarrying and sidehill gouging merging into short tunnels just previous to 1840; these methods were parallel with those used in England up to around the twelfth or thirteenth centuries, the tunnels seldom being over a hundred feet in length and poorly timbered so they soon caved in. In 1840, however, the tunnels appear to have been driven with more of an idea of some permanence and we find a crude sort of room being turned off of them. There was still no provision for ventilation, and the rooms were driven in any direction that took the fancy and usually only about fifty feet in length with scarcely any pillars between them. The next decade brought with it the first appearance of the double entry, to provide for circulation of the air in one and out of the other, and the introduction of the furnace to increase the volume of air moving. By 1870 the use of double entries had become general and we find evidence of laying the mines out with some degree of regularity, and of the rooms being driven on sights. Rope haulage engines had been installed as early as 1845 and before 1880 the mine locomotive and the power-driven ventilating fan were in use.

CHAPTER II

Modern Methods

OPENING A MINE

There are three general methods of opening a mine, depending upon the depth and angle of inclination of the seam. Where the seam lies horizontal and outcrops in the hillside, it is usually opened by a tunnel driven in the coal; this is called a drift mine and is the most economical method of development there is. When the seam outcrops on the surface, but is inclined at angles varying up to sixty degrees or more, it is opened by means of a tunnel following the coal down from the surface. This is known as a slope mine and it involves an immediate expenditure for mechanical equipment to hoist the coal from the mine.

Most of the coal mined up to the present time has been won through one or the other of these two methods, but with the gradual exhaustion of the surface coals it is becoming more necessary to resort to the third method, which is called shaft mining. This system is used where the seam lies at considerable depth and there is no outcrop within the limits of the property which it is proposed to develop. Even when outcrops are available for opening the physical conditions of the property, topography, etc., may be such as to make a shaft opening the most desirable method of working.

Before proceeding with the development of a coal property on any important scale a very thorough examination of it is made by the engineers, both for the purpose

of proving the actual existence of the coal and determining the best and most economical method of exploitation. The coal is proved up by opening prospect tunnels in the outcrop, examination of the seam in any contiguous mines, study of the State and government geological survey reports, and when the evidence obtained from these sources is not sufficiently positive, by drilling with a diamond drill. These drills bring up an actual core of the seam from one to three inches in diameter, giving the thickness very accurately as well as other information such as the character of the roof and bottom, inclination of the seam, and even a sample that can be analyzed if desired. The amount of work that will have to be done along this line will vary largely according to known characteristics of the seam; some seams are very irregular and require extensive prospecting while others are remarkably uniform over large areas. This is a matter that must be left to the judgment of the expert engineer and geologist.

The field examination having proved satisfactory, the data collected in the course of this is then studied by the engineers to determine the best method of procedure in developing the property. In a mountainous country the site for the opening will be limited to such points as it is possible to construct a railroad to. An attempt should also be made to have the opening at as low a point in the seam as possible in order to provide for gravity drainage by means of ditches and also to have the coal from the workings moving in a downhill direction as far as possible, to the opening. Due consideration will also be given to having adequate space for the construction of the surface plant, houses, etc., if these will be required.

The development of a drift or slope mine would involve no special deviation from the methods described

under Digging the Coal, page 69, but where it becomes necessary to sink a shaft the procedure is quite different. Shafts of the size necessary to provide for an average production are very expensive, costing from $200 to $500 or more per foot to sink and line, depending on the nature of the strata. It has become the custom in recent years, in fact the State mine laws now usually require it also, to sink two shafts within five hundred feet or so of each other,

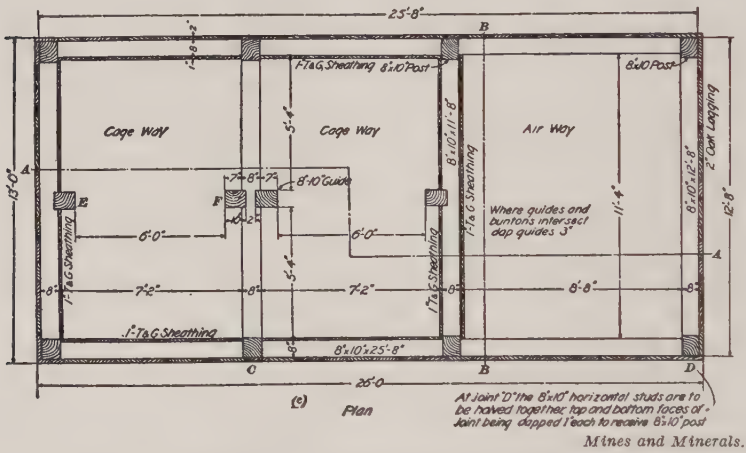


Fig. 10. Plan view of a typical present-day timber-lined shaft.

wherever operations of this kind are undertaken. Shafts in this country vary in depth from around one hundred to six hundred feet and considerably deeper in the anthracite regions, so it will be seen that a mine development of this kind involves a very heavy initial cost, though the cost per ton when the mine is finished may be infinitesimal.

A plan of a typical single shaft of the kind used before the duplicate shaft method was adopted is shown in Figure 10. This shaft is divided into three compartments, two cage ways or hoistways and an airway, the last being separated from the hoistways by an air-tight partition as

shown, one side being used for the main air intake for the mine and the other for the main return. The cage ways are also used for hoisting the coal from the mine and lowering the material down, and the air way would have a ladder or stairway in it and be used as a passageway for pipes, wires, etc. Vertical guides, *E* and *F*, are provided in the cage ways which act as a runway for the cage to prevent it from bumping the sides of the shaft when

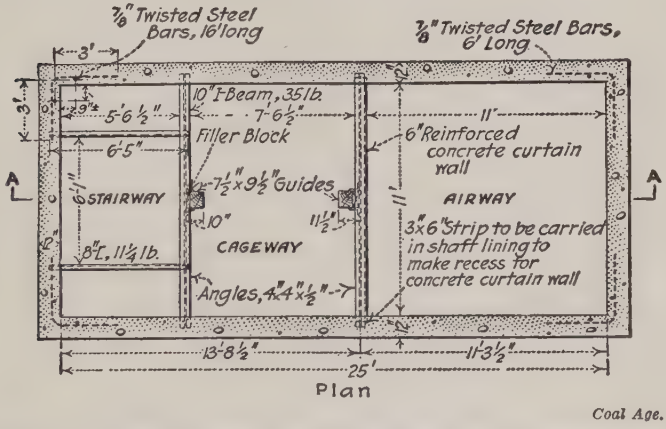


FIG. 11. Plan of a modern concrete lined shaft with dimensions and construction details.

being hoisted at high speeds. The entire shaft is timbered throughout in the manner shown.

Where duplicate shafts are used, one is designed as a hoistway for the coal and the other as an auxiliary hoist and for miscellaneous purposes, an example of the latter being shown in Figure 11. As will be observed the right half of the shaft is left free for use as an air way and the other half has a cage way for hoisting men and lowering material, and a stairway and two smaller compartments that can be used for pipes, wires, etc. This shaft is lined with concrete, which is coming rapidly into favor for

shaft linings, because it is more water-tight and less inflammable. Concrete shafts are usually made oval, elliptical, or even circular, instead of rectangular as here shown. European shafts are considerably deeper than in this country and they are nearly always circular and lined with brick, stone, concrete, and sometimes with iron segments.

SYSTEM OF WORKING

The systems of mining previously described were of such an elementary character that we have been able to portray these by means of word pictures. The advent of the large-scale operations in the nineteenth century, however, brought with it the introduction of very extensive complexities in the systems of working which we will now consider in some detail.

All systems of mining rest upon certain fundamental principles of a comparatively simple nature. There is, first, a system of tunnels, called entries, driven in the coal and designed for more or less permanent use in hauling the coal from the mine, passage of the main ventilating currents, drainage, etc. Since it is obviously impossible to pass a ventilating current both in and out of a single tunnel or entry, these are always driven in pairs, with a pillar of coal varying from twenty to fifty feet or more between. One of this pair of entries is used as a traveling way for air and for haulage purposes in transporting the coal out of the mine and is called the haulway and the other, being used exclusively for the passage of the ventilating current, is termed the airway or air course. The two together are usually designated as the Such-and-Such Entry.

This is the basic principle upon which all systems of mining rest and we will now follow up the method of procedure in detail. The Third Left Entry in the upper left-

hand corner of Figure 12 shows a typical entry in course of development. The air course and haulway which go to make up this entry were started at the same time from the Main Haulway and have been driven in some five hundred and fifty feet with connections between them, called crosscuts or break-throughs, at intervals of about

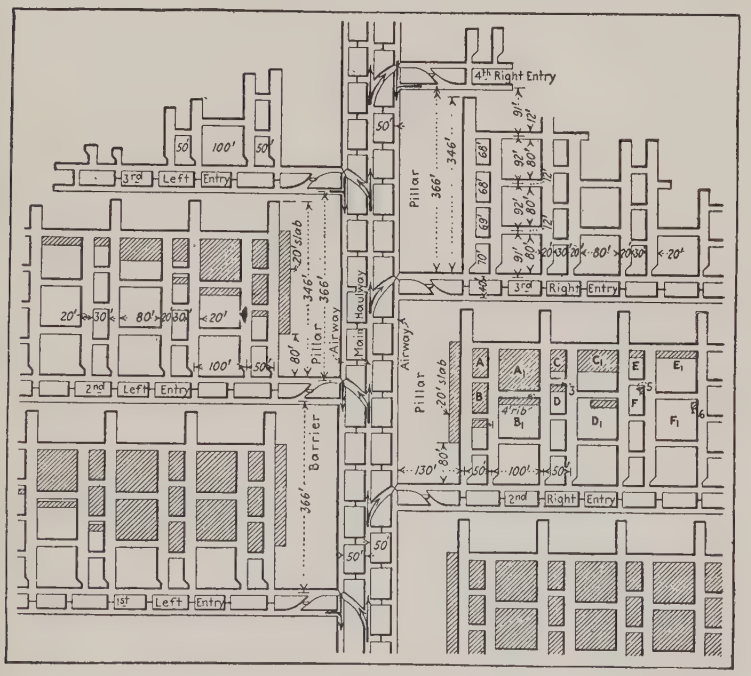


FIG. 12. A characteristic mine plan showing a system used in the New River field of West Virginia.

one hundred feet. It will be observed that all the crosscuts between the two entries, with the exception of the last, have been closed off with partitions of brick, stone, or boards which are variously known as stoppings or brattices. That part of the ventilating current entering from

the Main Haulway as indicated by the split arrow, is therefore obliged to travel into this last crosscut before it finds a means of egress; passing through this crosscut, it returns out the other entry to the airway of the Main Haulway, where it joins the main return of the mine, as indicated by the split arrow there. When the entries have progressed another hundred feet beyond this last crosscut, another will be made, the present one closed up and the air thus kept close up to the working face, the process being continued indefinitely as far as it is desired to go.

From the haulway of the Third Left Entry, there have been six working places for the miners started, these being called rooms. The room is where the bulk of the production for the mine originates, that obtained from driving the entries being more or less incidental. As soon as the room is driven up to the next entry it is abandoned, so it will be seen that its life is comparatively limited, in which respect it differs very widely from the entry. The problem of maintaining the roof in rooms is, therefore, of less importance than with the entries, so that the former are driven considerably wider and when the room is completed, the timbers are removed and the roof is allowed to cave in. The entries, on the other hand, are driven as narrow as adequate clearance for the mine cars will permit, so that the roof will be as self-supporting as possible.

The mine layout shown in Figure 12 is a very characteristic system of working, its salient features being a main haulway with cross entries feeding coal into it from the right and left. It will be observed that the Main Haulway is made up of three entries instead of two, this having been necessary in this case to provide a return airway on both sides for convenience in connecting up with the return airway of the cross entries. The middle entry of

these three is both the main air intake for the mine and the main haulway. The entire air supply of the mine passes through this entry, a portion being taken out at each cross entry, in a manner that will be explained later under Ventilation. The ideal haulage for a lay-out of this kind would include light gathering motors on each of the cross entries, assembling trips of anywhere from twenty to forty cars on switches near the main haul-way, where they would be picked up by a heavy motor and taken out to the tipple or shaft bottom, as the case may be.

It will be observed from this plan that a very consider-able area of coal is left unmined. Long experience in mining operations has proved the necessity of leaving in a large portion of the coal in the first mining. Where the protection of this kind is inadequate, the pillars that are left in will be crushed by a gradual subsidence of the roof, which may extend over the whole or a very large portion of the mine; phenomena of this kind, called squeezes, have been all too frequent in the past history of the mining industry, and once started they cannot be stopped until the floor and roof come together.

When a series of rooms have been completed, the pillars between them are then removed, care being taken to see that there are sufficiently heavy pillars surrounding that particular area to protect the adjoining workings from the resulting squeeze. Evidence of this practice can be seen in Figure 12, the crosshatched area indicating where the pillars have been drawn or are in course of being taken out. In the First Left Entry the extraction has been completed, with the exception of the last two pillars on the left, which are in course of being removed. It will be observed that the pillars next to the entry are left in as it is necessary to keep this open until the entry has

been driven out to the limit, and a similar heavy pillar has been left above to protect the Second Left Entry for the same reason. When these entries have been driven out to the limit, these pillars will be drawn on the second working, coming back. A very heavy pillar of about one hundred feet of solid coal is left on both sides of the Main Haulway, it being of the greatest importance that nothing happen to this. Squeezes of a local character are set up in the areas where these pillars are extracted, but so long as they are controlled in the manner here shown, they are of a beneficial effect in having a tendency to relieve the weight and pressure on the adjoining areas.

This particular method of working was originated for use in the New River field of West Virginia, where it is known as the eighty-foot Block System. It was designed by J. A. Graft, who described the method of drawing the pillars in an article in *Coal Age* as follows:

In a method that I have used successfully for two years and which is known as the 80-ft. block system the rooms are driven 20 ft. wide and in pairs, the pillars between the rooms in each pair being 30 ft. wide and between pairs 80 ft. It will be noted that crosscuts are driven more frequently between the rooms in each pair — that is, through the narrow pillar — than through the pillars between the pairs, which are wide.

In starting the pillar in the first room a 20-ft. slab is taken toward the main entries, thus reducing the barrier pillar next to the Main Haulway to 110 ft. in width. As is shown in the second right entry, a slab is then taken off pillars A_1 and A in rooms 1 and 2. At the same time a cut 1 is made across the pillar to the left of room 2 and also 4 ft. from the upper edge of the pillar B_1 to the left of room 3. In the 4-ft. web left in the wide pillar B_1 frequent cuts should be made, leaving in, however, most of the coal.

When pillars A_1 and A are slabbed off to half their thickness, start slabbing C_1 and C and at the same time start crosscuts in pillar D of room 4 and another in pillar D_1 of room 5. When the pillars A_1 and A are entirely removed and C_1 and C are partly mined out, pillars E_1 and E should be slabbed and crosscuts 5 and 6 in pillars F and F_1 of rooms 6 and 7 should be started. The props that are found in the area formerly occupied by pillars A and A_1 should be taken out and the top allowed to fall, first setting sufficient props or cribs to prevent falls

across the face of C_1 and C. When the entry has reached its limit all chain pillars and room stumps are to be drawn in retreat.

The panel system of working is shown in Figure 13, which is the standard plan of development adopted by the Pocahontas Coal and Coke Company for its tenants; this is a landholding company only, and in all leases to

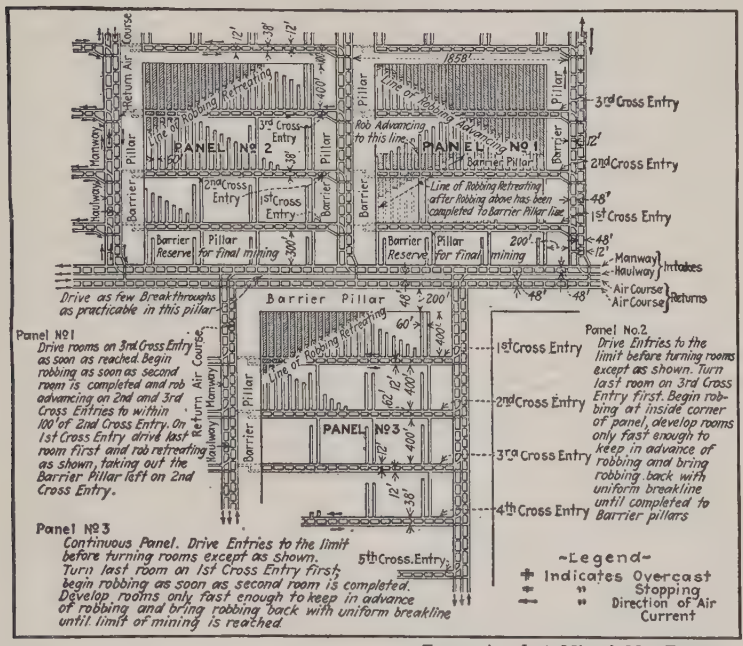

Return Air Course
Manway
Haulway
Barrier Pillar
PANEL No 2
PANEL No 1
PANEL No 3
3rd Cross Entry
2nd Cross Entry
1st Cross Entry
Barrier Reserve
Pillar for final mining
Barrier Pillar
Intakes
Returns
Air Course
Drive as few Breakthroughs as practicable in this pillar
Panel No 1
Drive rooms on 3rd Cross Entry as soon as reached. Begin robbing as soon as second room is completed and rob advancing on 2nd and 3rd Cross Entries to within 100' of 2nd Cross Entry. On 1st Cross Entry drive last room first and rob retreating as shown, taking out the Barrier Pillar left on 2nd Cross Entry.
Panel No 2
Drive Entries to the limit before turning rooms except as shown. Turn last room on 3rd Cross Entry first. Begin robbing at inside corner of panel, develop rooms only fast enough to keep in advance of robbing and bring robbing back with uniform breakline until completed to Barrier pillars
Panel No 3
Continuous Panel. Drive Entries to the limit before turning rooms except as shown. Turn last room on 1st Cross Entry first; begin robbing as soon as second room is completed. Develop rooms only fast enough to keep in advance of robbing and bring robbing back with uniform breakline until limit of mining is reached
5th Cross Entry
4th Cross Entry
Line of Robbing Retreating
Rob Advancing to this line
Line of Robbing Retreating after Robbing above has been completed to Barrier Pillar line
-Legend-
Indicates Overcast
" Stopping
" Direction of Air Current

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FIG. 13. Composite plan showing various mining systems of the Pocahontas Coal and Coke Company in West Virginia.

the operating companies it reserves the right to prescribe the system of working in order to assure a maximum recovery of the coal. This plan and the method of working have been previously described in the author's book on "Coal Mining Costs", and in other places.

A study of this plan will show that the system of min-

ing shown in Figure 12 might, with some modifications, be considered as a unit or a panel of this system; in other words, the methods shown in Figure 13 contemplate operations on a very broad scale, made up of what might very properly be considered a series of entirely independent mines, or panels as they are termed. Thus it will be observed that we still have the same double cross entries from which the rooms are turned, feeding into the three-entry mains, running vertically in the plan. In Figure 12 this was the last channel through which the coal passed on its way to the shaft bottom or surface, but in this larger scheme of operation it will be observed that these main entries all feed into still another and larger four-entry main which might be designated as a super-main entry.

Operations on the scale shown in this plan contemplate the production of very heavy tonnages, necessitating the employment of large numbers of men and the supplying of large volumes of air. Congestion of any description in this super-main entry would be fatal to the economical operation of the whole plan and it was the realization of this that led to the adoption of the four-entry system for the purposes here indicated. As will be noted on the plan, two of the entries are used exclusively for the return airways of the mine and two for the intake, these last being used as a manway and haulway, respectively, as well. The haulway on a super-main system of this description would be equipped with a track that would compare with some of the second-rate railroads over which the heavy tonnages could be moved with the greatest dispatch.

Three distinct methods of procedure in mining and drawing the pillars are shown in this plan, one for each panel, which are described in notations on the drawing for the benefit of the reader who may wish to follow this

subject out in greater detail. The salient feature of the plan as a whole is the development of self-contained operating units of relatively large capacity and isolated from the balance of the mine by means of heavy barrier pillars. A particularly admirable feature of this system is that, considered in the broader aspects, it contemplates the total extraction of the coal as the mine advances, with the exception of the barrier pillars, which can be easily and economically recovered when the mine is finished.

A study of the principles developed in the foregoing descriptions will give the reader a grasp of the general methods of procedure applied to all systems of coal mining as practiced to-day. There are some very broad departures from these general methods, as, for instance, in those parts of the anthracite regions where the seams are very thick and steeply inclined, but in the last analysis, they too must conform to the basic principles governing the laws of roof sustenance, ventilation, and haulage as already outlined. Variations in the systems of mining will occur even in the same field and still more important modifications in different fields. No one can say what is the typical system of mining and it is obviously not within the scope of a work of this character to enter into a discursive analysis of the different methods, all of which rest upon the fundamental principles already outlined.

DIGGING THE COAL

In the preceding section we have covered the general system of mining in its broader aspects, showing how the coal is transported underground, adequate ventilation provided, and measures taken to control the roof action. We will now take up the methods of actually mining coal in the working places.

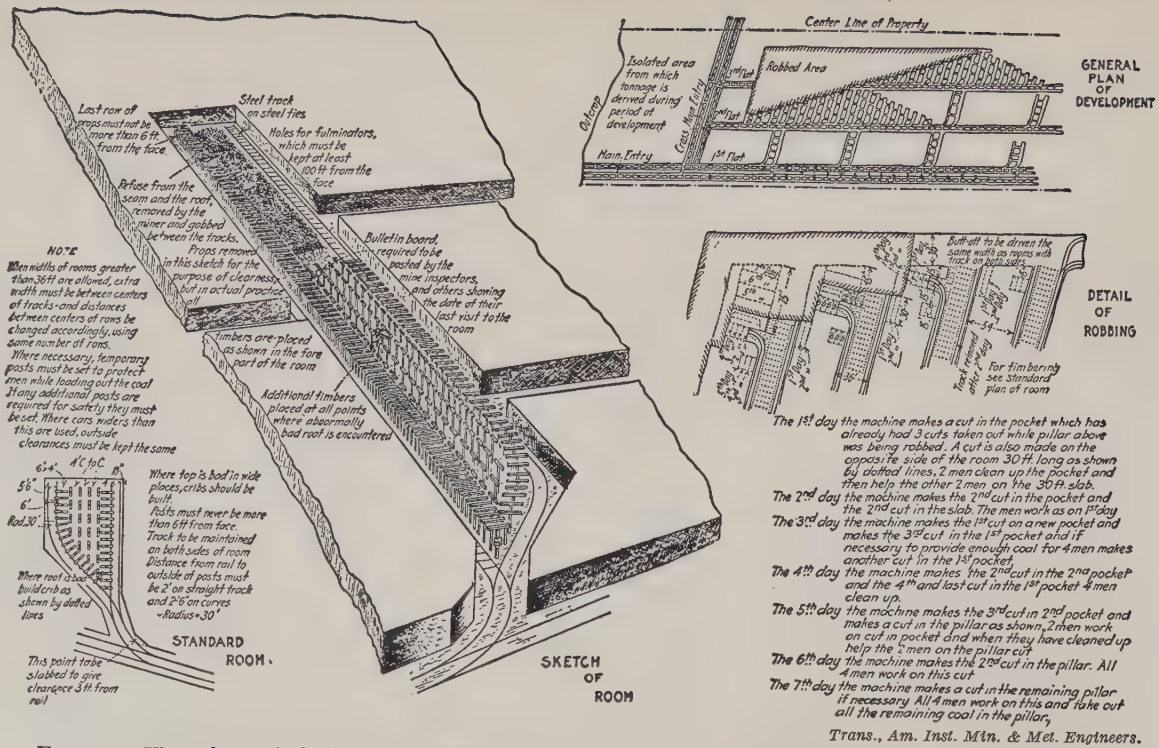
The room is the last subdivision in the intricate mine

system and is also the determining factor in the productive capacity of the mine. When a mine is being opened the amount of coal obtained from driving the entries is comparatively negligible and the mine cannot be regarded as on a really operating basis until the entries have been extended far enough to permit of opening up a considerable number of rooms. From a production standpoint the room is the backbone of the mine.

In Figure 14 is a sketch of a typical room as it would appear in the mine if the roof were lifted off. The size of the rooms varies considerably in different fields according to roof conditions, and may be anywhere from ten to fifty feet wide and two hundred and fifty to four hundred feet long; the one here shown is thirty-six feet wide with a length of four hundred feet when completed. The room is usually driven the full thickness of the coal and this consequently determines the height; they may sometimes be as low as two feet or anything up to eighty feet, though special methods of working are necessary where the seams are more than ten to fifteen feet thick. The room here shown is in a seam eight feet thick, which forms about ideal working conditions.

The room starts from the entry as shown at the bottom of the sketch with an angular cut in order to provide an easy curve for the track and is driven narrow for the first twenty feet so as to leave a substantial pillar of coal to protect the entry from the possibility of a squeeze. It is then gradually widened out to its full width and at the same time set on its true course by means of sights placed by the engineers, which are later extended up into the room when required.

The room here shown is relatively wide, so that two tracks are necessary, and it will be observed that a second track is immediately started off to the right where the


Steel track on steel ties
Last row of props must not be more than 6 ft. from the face
Holes for fulminators, which must be kept at least 100 ft. from the face
Refuse from the seam and the roof, removed by the miner and gobbed between the tracks.
Props removed in this sketch for the purpose of clearness, but in actual practice all
Bulletin board, required to be posted by the mine inspectors, and others showing the date of their last visit to the room
Timbers are placed as shown in the fore part of the room
Additional timbers placed at all points where abnormally bad roof is encountered
NOTE
When widths of rooms greater than 36 ft are allowed, extra width must be between centers of tracks and distances between centers of rons be changed accordingly, using same number of rons.
Where necessary, temporary posts must be set to protect men while loading out the coal
If any additional posts are required for safety they must be set. Where cars wider than this are used, outside clearances must be kept the same
Where top is bad in wide places, cribs should be built
Posts must never be more than 6 ft from face.
Track to be maintained on both sides of room
Distance from rail to outside of posts must be 2' on straight track and 2'6" on curves
Radius = 30'
Where roof is bad build crib as shown by dotted lines
This point to be slabbed to give clearance 3 ft. from rail
STANDARD ROOM.
SKETCH OF ROOM
Center Line of Property
Isolated area from which tonnage is derived during period of development
Robbed Area
Outcrop
Coal to Mine Entry
Main Entry
1st Lift
2nd Lift
3rd Lift
1st Floor
GENERAL PLAN OF DEVELOPMENT
Butt all to be driven the same width as rooms with track on both sides
Track removed after robbing
For timbering see Standard plan of room
DETAIL OF ROBBING

The 1st day the machine makes a cut in the pocket which has already had 3 cuts taken out while pillar above was being robbed. A cut is also made on the opposite side of the room 30 ft. long as shown by dotted lines, 2 men clean up the pocket and then help the other 2 men on the 30 ft. slab.

The 2nd day the machine makes the 2nd cut in the pocket and the 2nd cut in the slab. The men work as on 1st day

The 3rd day the machine makes the 1st cut on a new pocket and makes the 3rd cut in the 1st pocket and if necessary to provide enough coal for 4 men makes another cut in the 1st pocket

The 4th day the machine makes the 2nd cut in the 2nd pocket and the 4th and last cut in the 1st pocket 4 men clean up.

The 5th day the machine makes the 3rd cut in 2nd pocket and makes a cut in the pillar as shown, 2 men work on cut in pocket and when they have cleaned up help the 2 men on the pillar cut

The 6th day the machine makes the 2nd cut in the pillar. All 4 men work on this cut

The 7th day the machine makes a cut in the remaining pillar if necessary All 4 men work on this and take out all the remaining coal in the pillar,

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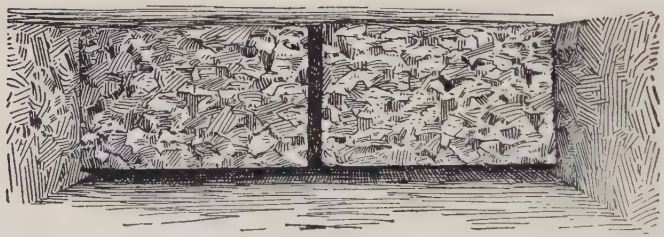
FIG. 14. View of a typical mine room, assuming the roof to have been removed, showing arrangement of tracks, timbering, etc., and the method of procedure in robbing or drawing the pillar after the room is finished.

room begins to widen out. In rooms up to around twenty feet in width, a single track located in the center of the room would be used. Roof conditions not being very favorable, the room is rather closely timbered with props having crossbars on top, as is clearly shown in the sketch. After the room has been driven in from fifty to seventy-five feet, it becomes necessary to make some provision for ventilation, so a crosscut to the next room on the right is driven, the balance of the crosscuts being staggered on alternate sides of the room as shown. Proceeding up the room we observe that provision is made for disposing of roof falls and any refuse matter there may be in the



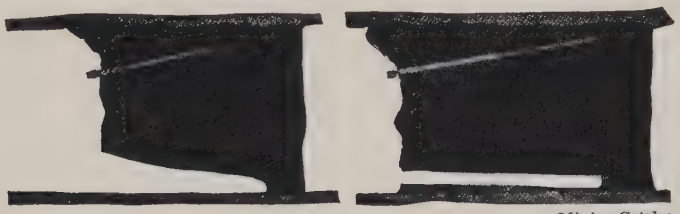
Mining Catalog.

FIG. 15. A typical room face with both a center cut and an undercut.

seam when it is mined, by piling this in the center of the room between the tracks, forming what is known in the mining parlance as the gob. There is a rather unexpectedly large amount of such accumulations in the course of the mining operations, and where the seams are thin and the rooms narrow, it is frequently necessary to load out a considerable amount of this in the mine cars, which is obviously more expensive.

The end of the room is called the face and it is here that we find the mining operations under way. Figures 15, 16, and 17 show some of the more important methods of mining. Figure 15 shows a room face that has been under-

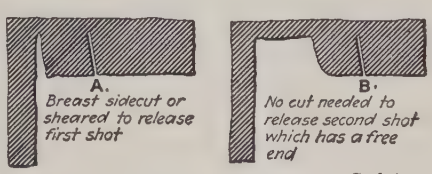
cut and also has a center cut and is ready for blasting. Figure 16 is a cross section of two coal faces that have been undercut by different methods, and with the holes drilled near the top and ready for blasting also. The cut on the left has been made by a puncher machine and



Mining Catalog.

FIG. 16. Two characteristic undercuts and shot holes for blasting the coal down.

is very similar to the cut that would be made in hand mining; the cut on the right is an example of a chain-machine job. Figure 17 is a plan view of the left-hand corner of a working face, showing another method of procedure; in this method a vertical cut is made along the side, as shown, a hole drilled at *A*, charged with powder, and the coal between it and the cut blasted out, the process being continued clear across the working face, without the necessity of further cutting, as shown in the second figure on the right.



Coal Age.

FIG. 17. Method of blasting a coal face after a single cut on the left rib.

The cuts shown in these sketches are now usually made by machines in a manner that will be taken up later, though formerly this was all done by hand with a miner's pick; it is very laborious work at which the old-time miner became remarkably adept. The blasting, or shooting as it is known in mining circles, is done with a very slow

powder in order to avoid breaking the coal more than necessary. Formerly ordinary gunpowder was used for this purpose and this was a prolific cause of the numerous mine explosions we had in those times due to blown-out shots; powders that give off little or no flame, known as permissible explosives, are now generally used and have done away with this trouble in a large measure.

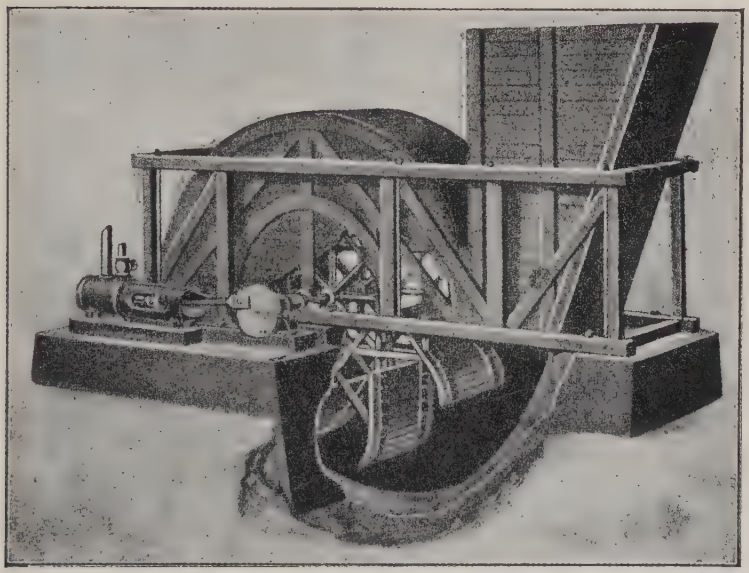
Regulations governing operations in the rooms vary in all districts and in the union fields are very rigidly fixed in the wage agreements between the miners and the operators. There may be from one to four men assigned to a room and they are paid on a tonnage basis for the coal they mine, load, and send out to the tipple. It is the usual custom to require them to keep the track in repair and laid up to the face and keep their rooms timbered up, the company supplying the material for all this work. Where there are no machines they are required to do their mining, bore, and load the holes for shooting the coal and finally load the coal on the cars when it has been broken down. The miner furnishes his own powder, which is his principal item of expense. He is his own boss in a large measure, free to come and go as he chooses within certain limits, and where the working conditions are favorable he is not unpleasantly situated and receives a substantially higher scale of remuneration than the same class of labor in other lines. Once accustomed to the mines the average laborer prefers the inside work to anything on the outside.

The work of driving entries, crosscuts, etc., called narrow work, differs from that of driving rooms because the miner has a shorter face to work on and is consequently not able to mine so much coal. Miners employed on work of this kind, therefore, are allowed additional remuneration per yard of such places driven, this being

known as yardage. The more skillful miners are usually employed on this work and where conditions are favorable they frequently make very large wages.

MINE VENTILATION

We have already noted the introduction of the first mine fan in the year of 1844; this was known as the Guibal



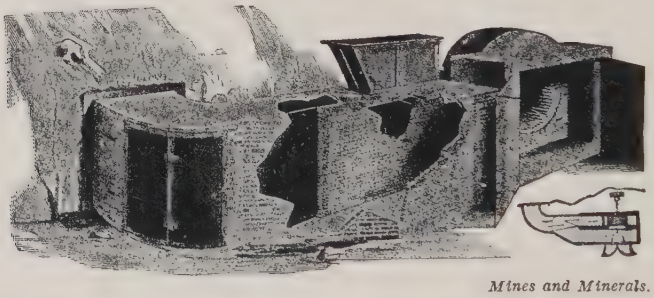
Coal Age.

FIG. 18. The Guibal mine ventilating fan, a heavy slow speed type that is now becoming rapidly obsolete. Section removed to show blades.

type, named after its inventor, an eminent Belgian engineer of the time. This fan was used quite extensively for many years having been quite popular in the anthracite regions in this country until comparatively recent times. One of the modern adaptations of this type of fan is shown in Figure 18 in which it will be noted that timber construction is used in contradistinction to the modern use of steel and concrete or brick. These fans

were designed to run at low speeds of about fifty revolutions per minute as compared with one hundred and fifty for the more recent types, and they were made in extraordinary sizes, sometimes as much as forty-five feet in diameter, in order to produce the required volume of air. Construction difficulties were encountered in making them so large which were both expensive and impossible to solve in a satisfactory manner, so that the fan has been gradually superseded by the smaller high-speed type.

A typical installation of the high-speed fan is shown in Figure 19. This is a reversible single-inlet type of



Mines and Minerals.

FIG. 19. The modern type of steel and masonry ventilating fan.

fan, taking or exhausting the air on one side only, as will be seen by reference to the sketch in the lower right-hand corner. With the doors in the position shown in this sketch, the fan forces the air into the mine but the action can be readily reversed by closing the two exterior doors, shifting the inside one to the position indicated by the dotted line, and changing the direction in which the fan operates, the air then being exhausted from the mine and out through the involute chimney shown in the picture.

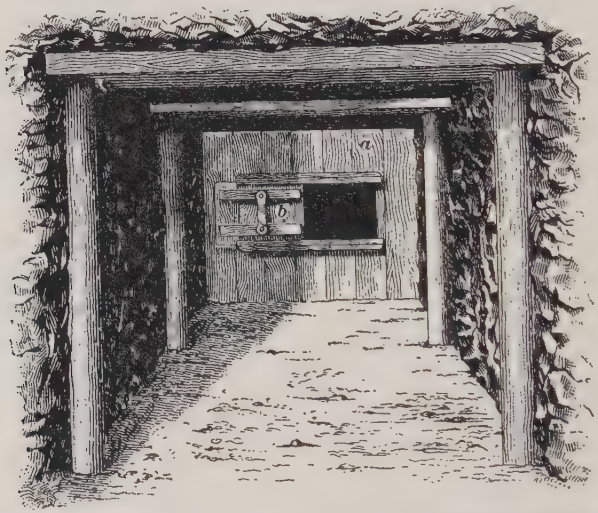
It will be observed that the fan is located to one side of and out of line with the entrance into the mine, the ob-

ject of this being that in event of an explosion in the mine, there will be less probability of the fan being wrecked; it will also be noted that steel explosion doors are installed directly in line with the mine entrance which are designed to blow open and absorb the main force of a possible explosion. A heavy explosion extending to the mouth of the mine is quite apt to wreck the ventilating equipment, making it impossible to proceed with the rescue work until this has been restored.

Mine fans are usually designed to run in one direction, either forcing or exhausting the air as may be best suited to the particular conditions for which it is built, but it is customary to make them reversible to provide for any emergency in the mine; they give their greatest efficiency when running in the direction for which they are especially designed, but in event of an emergency situation arising, this would be a matter of small moment for temporary purposes. Some fans are now being designed to give an equal efficiency when running in either direction and their action reversed with the change in the season, in order to take advantage of the changes in the natural ventilation.

The modern fan is a high-powered apparatus developed to a very high degree of efficiency. The fan shown in Figure 19 would probably be capable of producing between three hundred thousand and four hundred thousand cubic feet of air per minute, depending on the conditions under which it was working, and there are fans in use handling up to six hundred thousand cubic feet per minute. A fan of this latter type would be approximately twenty feet in diameter and equipped with about sixty-four vanes or blades. The air pressures developed in handling such large volumes of air are difficult to provide for in ordinary mine operations, so that it is not likely that there will be much further increase in the size of the present mine fan.

The reader who has followed through the preceding discussion of the way in which ventilating currents are conducted at will to the various parts of the mine has no doubt pondered as to just how this was accomplished. The distribution of the ventilating currents is effected by what may be termed negative or obstructionist methods; that is, we can readily limit the amount of air passing through any entry or crosscut by partially closing it up



Mines and Minerals.

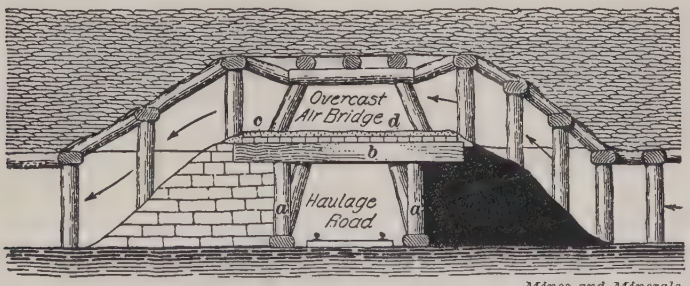
FIG. 20. An underground brattice with a regulator for controlling the ventilating current.

until just the desired quantity is passing and thus forcing the balance into other channels, as may be required. By doing this with each division of the air, we finally arrive at the exact distribution desired.

For purposes of demonstration, let us refer again to the Third Left Entry in the mine plan shown in Figure 12. This is a comparatively short entry, requiring considerably less air than the others below it which may be driven in

for very considerable distances. The resistance to the air in passing around this short loop in the Third Left Entry would obviously be substantially less than in passing all the way in and out the much longer entries below. Following the line of least resistance, the bulk of the air from the Main Haulway would, therefore, tend to pass through this shorter route in the Third Left Entry where it was least needed, and it becomes necessary to obstruct its passage in order to force more air into the other entries.

There are several methods of accomplishing this, one of which would be to install a regulator, as shown in Figure 20, at some point along the entry. This regulator is



Mines and Minerals.

FIG. 21. Construction of a mine overcast used where two air currents cross.

a simple partition or brattice, built up of boards *a* and containing a sliding door *b* which can be set to allow just the proper amount of air and no more to pass through. It is customary in mining operations to make periodic checks of the amount of air passing through the different entries by means of instruments designed for measuring air velocities, and the proper aperture in the regulator would be thus determined from time to time as the workings extended.

Referring once more to Figure 12, it will be observed that at each one of the cross-entry turnouts from the

Main Haulway we have two opposing air currents apparently crossing each other; that is, where the intake into the entry crosses the main return for the mine in the airways on both sides of the Main Haulway. Where such a condition occurs, it is necessary to install an overcast such as is shown in Figure 21. This consists of breaking down a section of the roof and timbering it up in some such manner as shown with an air-tight bridge over the top of the haulway. Where overcasts are to be of a more or less permanent character, they are frequently built of masonry or concrete.

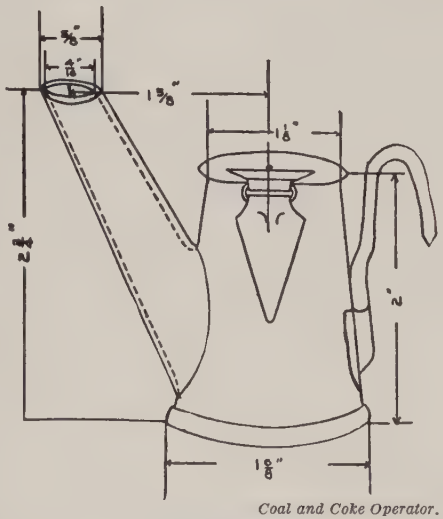
MINE LIGHTING

Methods of illuminating the underground workings have progressed from torches fed with tallow, to the tallow candle, then to the oil lamp or torch, still used to some extent but now largely replaced by the carbide lamp and both portable and fixed electric illumination of various kinds. In the modern electrically operated mine of to-day the incandescent lamp, common to all households, is used very extensively for lighting points of principal activity, such as the shaft bottoms where the entire tonnage of the mine is handled, main switches where the trips are made up, etc. Main haulways handling large tonnages are also sometimes lighted, or partially lighted with occasional lamps, and some of the more advanced companies have adopted the practice of installing a fixed light at the working face in every room.

It must be remembered, however, that even a moderate-sized mine will have several miles of haulways and manways in more or less continual use, so that the cost of providing permanent fixed lights throughout the mine would be prohibitive. The portable lamp is, therefore, an essen-

tial part of the equipment for every underground workman.

An example of the typical oil lamp, that is now gradually disappearing from the mines, is shown in Figure 22, which also gives its principal dimensions in inches and fractions thereof. The wicking for this lamp is twisted in a roll sufficiently large to make a tight fit in the spout, through which it is pulled from the inside of the body. The oil is placed in the body of the lamp through the hinged door at the top. This lamp still enjoys a certain popularity over the carbide lamp because of its larger flame, which is less easily extinguished in a specially rapid air current. On the other hand it almost invariably drips oil which mixes with the smoke and soot to form a particularly tenacious and disagreeable form of dirt that is exceedingly difficult to remove.

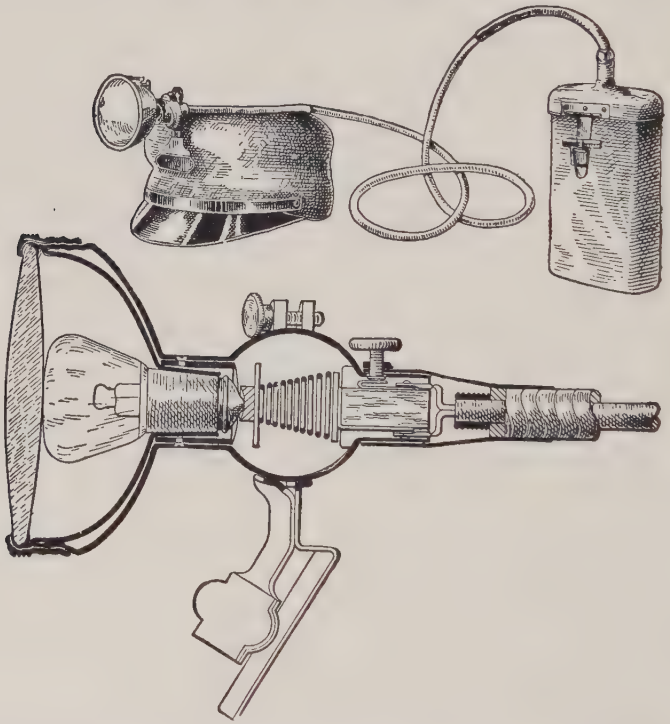


Coal and Coke Operator.

FIG. 22. The old type of oil lamp now becoming obsolete.

The portable electric cap lamp is shown in Figure 23. In the upper part the lamp is shown attached to the miner's cap with the connecting cord to the storage battery which is carried on the belt. Below is an enlarged sectional view through the lamp, showing the details of construction. These lamps have come into considerable favor in recent years, particularly in gaseous mines where

they are as safe or safer than the oil safety lamp and eminently more convenient, though they cannot, of course, be used for testing purposes. The lamp is clean, cannot be extinguished by the air currents like the flame lamps, and operation costs are not excessive. The initial cost



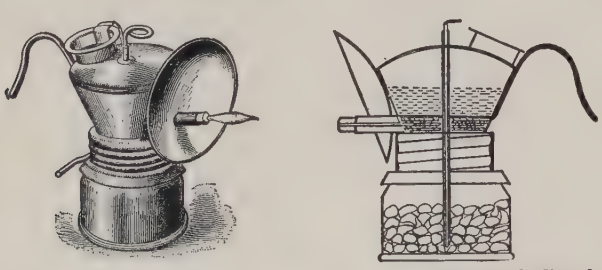
Coal Age.

FIG. 23. The modern electric cap lamp with an enlarged cross section of the lamp proper showing construction details.

is, however, relatively high as compared with the flame lamps and the miners find the cord objectionable for the reason that it is liable to catch in projecting timbers, etc.

A sectional and perspective view of the carbide lamp is shown in Figure 24. The carbide is placed in the bot-

tom part by unscrewing this from the body of the lamp and water is put in the upper part through the cap shown in top of the lamp. The water passes down into the carbide chamber through the vertical tube in which there is a device for controlling the flow so as to generate the required amount of gas, which, in turn, passes up and out through the burner shown in the lower center of the reflector. The lamp as a whole is simple, easily operated and the better types stand up very well under the hard usage in the mines. The chief difficulty lies in maintaining a uniform flow of gas, the supply tending to fluctuate and produce a flame of varying intensity. These lamps



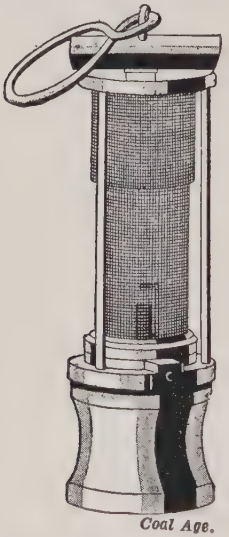
Mines and Minerals.

FIG. 24. The acetylene cap lamp, now the most popular type used.

are comparatively cheap and economical to operate and clean, though a slight leak in the carbide chamber produces a very disagreeable and penetrating odor.

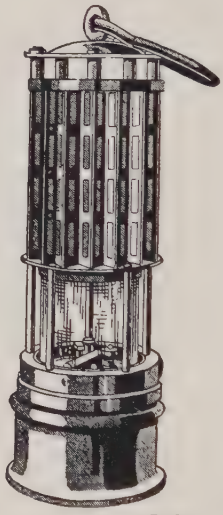
The principle of the safety lamp has already been described on page 54 and we show two of the more popular types of this lamp in Figures 25 and 26. The type shown in Figure 25 is lighter and is more popular with the firebosses whose duty it is to inspect the mine for gas before the men enter in the morning. It is an oil-burning lamp and is called the Davy lamp, taking its name from the inventor of the safety lamp, Sir Humphry Davy. The oil and lamp proper are contained in the bottom cylinder,

which can be unscrewed for purposes of cleaning, filling, and lighting. The gauze surrounding the flame is clearly shown and at the top it will be noted there is a double gauze, this being the part where the gas burns within the lamp; the extra gauze is used to provide additional safety. The top has a handle by which it may be carried in the mine and it makes a sturdy convenient lamp for the purpose for which it is intended.



Coal Age.

FIG. 25. The Davy safety lamp.



Coal Age.

FIG. 26. The Wolf safety lamp.

The lamp shown in Figure 26 is known as the Wolf type; it is considerably heavier than the Davy from which it differs in other respects as well. As will be observed, a glass cylinder has been inserted at the bottom, the object of this being to give a better dispersion of the light than can be obtained through the wire gauze. The gauze cylinder fits snugly on top of the glass and is surrounded by a metal casing resembling a ventilator in some respects, which is called the bonnet; the object of this bonnet is to

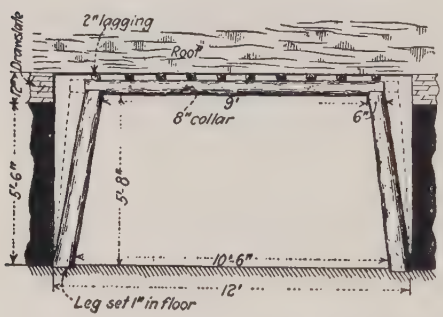
protect the gauze from damage caused by rough usage, keep it clean, etc. This lamp burns naphtha or gasoline and has a device for lighting it when closed, which is a great convenience in very gaseous mines where no open lights are permitted. The lamp is also supplied with a locking arrangement, when so desired, which makes it impossible to open except by means of a heavy magnet which is kept in the lamp room on the surface. The object of this is to guard against the miners opening the lamp in dangerous mines to light their pipes or for any other reason. This lamp is more adaptable for general mine usage than the Davy, as it is safer in the hands of an inexperienced man, gives substantially more light, and is heavier and generally more foolproof throughout.

MINE TIMBERING

The timber required in a mine may vary from none at all up to an almost incredible amount, this depending largely on the roof conditions, but also in a considerable measure on the intelligence with which the system of mining has been worked out and applied. There are mines with an exceedingly hard sandstone roof, almost impossible to break, which may never require a stick of timber, practically speaking. Such a roof as this, however, must be watched carefully as it tends to give a false sense of security that leads to a disrespect for adequate pillars and which will ultimately result in a squeeze if carried too far. A squeeze with a hard roof of this kind is much more difficult to control than where the roof breaks easily, but properly handled this type of roof presents the ideal mining conditions; other conditions being equal, the cost of production at such a mine will be well under that of an operation with a poor roof.

There is a fairly representative sprinkling of sandstone

roofs throughout the mining regions but the dominant type of roof generally encountered is shale. Roofs of this kind vary quite widely also, depending on the consistency of the shale. Where this is firm, hard, and well stratified it forms a very good roof, quite comparable with some of the softer sandstone types, but when the shale is soft and loosely bound it will be found difficult to hold. This is the condition under which timbering becomes necessary and when one recalls that some two hundred and ten million cubic feet of timber are consumed annually by the coal mines of this country, it will be seen that this is an important element in the cost of coal.

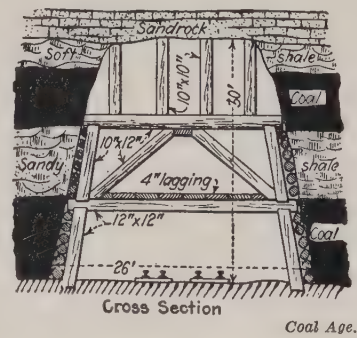


Coal Age.

FIG. 27. Typical set of round timbers with lagging on the top.

A very typical form of entry timbering is shown in Figure 27. It will be observed that the timber set, as it is commonly called, is made up of three members, two posts or legs and a crosspiece or collar. These sets may be placed at regular intervals, usually about every five feet, or set at isolated points along the entry wherever the roof shows indications of weakening. Where the roof is so soft that it threatens to cave between the five-foot sets, longitudinal pieces called lagging are placed on top of the collars. If the roof is very bad and tends to settle heavily on the collars the distance between sets is reduced and under the worst conditions it becomes necessary to place the sets immediately against each other, thus forming a continuous wall of timber on both sides and the top of the entry.

Mine timbers serve their most useful purpose in preventing the initial start of the caving process; once this gets under way and the break extends for only twenty feet or so into the overlying strata it will be readily seen that the resulting loads would be far greater than the holding strength of any type of timbering, with the exception of a solid crib. An example of a cave of this description that extended for some twenty-five feet to an overlying strata of sandrock is shown in Figure 28. A cave of this magnitude becomes a very expensive liability to the mine since it all has to be loaded out and an elaborate system of timbering installed to prevent it from extending farther.



Coal Age.

FIG. 28. Example of special timbering where a heavy fall had occurred.

Steel shapes have come into some use for mine timbering and for certain purposes they are finding a wide application. They are somewhat more expensive in first cost than wood, less flexible, and more difficult to adjust to special conditions that may arise, so they have not come into general use. Where a specially difficult roof condition exists in a permanent part of the mine they are frequently used, an example of this being shown in Figure 29, which is an application of steel timbers to a large entry in the anthracite regions. As will be observed they are set in much the same manner as already described, the posts being joined to the collar by means of angle irons and the whole bolted together. Lagging of old iron rails was put in on top of the collar and behind the posts, the whole giving a very strong and permanent construction.

Where the timber-lined rectangular shaft is used there is a great deal of timber required for these also, it usually being necessary to line them for their entire length. Shafts in the bituminous regions are up to six hundred feet in depth and they are considerably deeper in the anthracite regions so it will be readily seen that the timber for this lining is an important consideration. An example of a timber-lined shaft was shown in Figure 10, page 60,

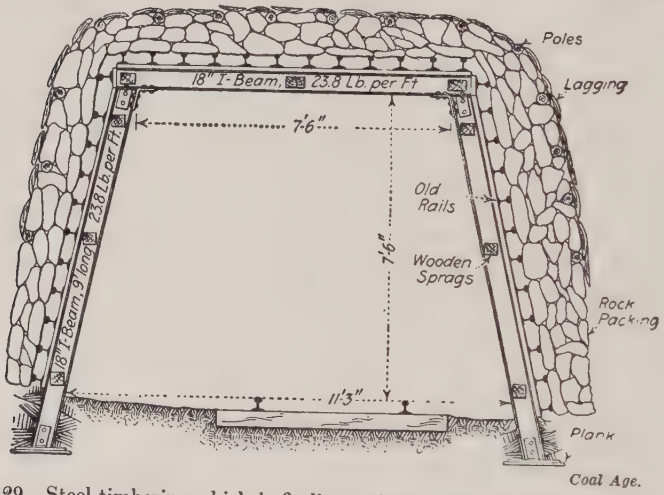


FIG. 29. Steel timbering which is finding wide application for special purposes.

which gives a plan view of a single timber set, these usually being placed five feet apart, the distance varying according to the character of the strata. Only sawed timber is used for this purpose, that ordinarily used in the mine being rough round timbers.

The growing scarcity and increased cost of mine timber is one of the important economic problems of the coal industry to-day and a continuation of the increase in these costs at anything like the rate of the past decade would make the use of timber almost prohibitive in the

near future. According to a combined study of the situation conducted by the U. S. Bureau of Mines and the Forest Service, and published in *Coal Age*, in 1923 the cost of mine timber at the Illinois mines just about doubled during the seven years from 1914 to 1921. Five-foot props that cost five cents in 1914 had increased to ten cents each in 1921, but the increase was less in the larger sizes, the seven-foot prop costing seventeen cents and twenty-four cents respectively, in the two periods and the nine-foot prop thirty cents and thirty-five cents. This increase has been continuing for many years, the average cost of round timber in 1905 being six cents per cubic foot as compared with a cost of seventeen cents and upward in 1921. The cost of mine timber at the Illinois mines in 1921 ranged from three to ten and one half cents per ton of coal produced, with an average of about four and seven tenths cents. The consumption of timber ranges from 0.09 to 0.39 cubic foot per ton of coal produced with an average of 0.23.

DISASTERS AND MORTALITY RATES

Coal mining takes a position well up to the front among the hazardous occupations, though by no means in the lead, being less hazardous than some of the other great basic industries, such as railroading. In the list of all occupations in Ohio and Pennsylvania, the compensation risks on those engaged in the mining industry are ten per cent. from the top in point of cost; that is, the hazards are greater in ten per cent. of the industries and less in ninety per cent. of the others.

The death toll due to accidents in the mining industry averages around two thousand a year or about four lives for each million tons of coal produced. While this composite figure seems an exorbitant price to pay for our fuel

supplies, it dwindles into insignificance as compared with accidental deaths in everyday life where, for instance, the automobile in an average State like Ohio kills nine hundred people a year.

Contrary to the general belief, the spectacular mine explosions, which receive such wide publicity in the daily press because of their peculiar value in a news sense, are responsible for only a small percentage of the mine fatalities. Under normal conditions the individual deaths resulting from falls of roof and coal amount to more than from all other causes. The high proportion of accidents from this cause is due to the impossibility of giving adequate supervision to the work of each miner, together with an inherent carelessness on his part and general low average of intelligence. The territory to be covered by the mine foreman and his assistants is so great and their attention diverted in so many directions that it is impossible for them to give more than a cursory consideration to the roof conditions in all the numerous places where the miners work. Assuming that the operator furnishes an adequate supply of timber for making the place safe, the main burden of the responsibility must then rest upon the miner himself. The fatality rate from this cause varies from 2.30 to 2.83 per thousand employed underground.

Haulage accidents in transporting the coal underground is the next important cause of mine fatalities, amounting to about seventeen per cent. of the total. These accidents are caused by the mine cars and locomotives and are frequently due to the miner riding on the trips, contrary to the regulations. Accidents from this cause amount to 0.81 to 0.99 per thousand of underground employees and appear to be showing a tendency to increase.

The fatality rate for mine explosions varies over a very

considerable range, but usually within the limits of 0.25 to 1.04 per thousand of employees. The mine explosion originates from two causes, the ignition of a standing body of methane gas or the ignition of the coal dust by a blownout shot in blasting, thus propagating an explosion that may continue indefinitely through all parts of the mine. Quite frequently the explosion is due to a combination of these causes. Some conception of a gas explosion can be gained by picturing a room full of ordinary illuminating gas in a dwelling house which is ignited. If the percentage of gas present in the air is less than six or greater than twelve it will not ignite. At these two percentages it will ignite with difficulty but burn with an intense suffocating heat fatal to any one who breathes it. Halfway between these two percentages the gas will explode with extreme violence, sufficient to blow down the walls of an ordinary dwelling if confined.

A blownout shot, sometimes called a windy shot, is one where the hole has not been properly located, so that instead of breaking down the coal the force of the explosion is directly out of the hole itself. A shot of this kind would be about the equivalent of discharging a large-caliber shotgun charged with several pounds of powder. The violent force of the blast fills the air with the freshly mined coal dust in the vicinity of the working place and the dust is exploded by the intense flame from the shot hole. The explosion may be purely local and of no serious consequence but where conditions are propitious it will extend to other working places, gaining fresh momentum as it proceeds and thus sweep through the entire mine. Explosions of this latter kind are of almost incredible violence, demolishing surface structures in the vicinity of the mine opening, from which the heaviest kind of material is sometimes blown for great distances. In the mine large

timbers are splintered to the size of toothpicks as though struck with lightning; track is torn up and the largest sections of rails twisted into shapes like a rope while, as commonly expressed, the shoes are sometimes literally blown off the men.

A list of the major mine disasters in this country is given in Table 9 of the appendix, in which it will be noted that the first important disaster occurred at the Avondale Colliery at Plymouth, Pennsylvania, in 1869, costing the lives of 179 men, two of whom died in their attempts to rescue their comrades. This was due to a fire in the shaft which cut off both the air supply and the only means of escape for the men and brought with it the lesson that duplicate shafts must be sunk at all important operations, a law that is now a part of nearly all the mining codes in the different States. In 1902 there were two large explosions, one at Fraterville, Tennessee, costing the lives of 184 men and the other at the Rolling Mill mine in Pennsylvania where 112 men were lost. The Hanna, Wyoming, explosion with its toll of 169 lives occurred the year following and in January, 1904, the Harwick mine in Pennsylvania exploded, killing all of the 179 workers who were in it at the time. In 1905 a mine at Virginia City, Alabama, exploded, exacting a toll of 152 lives.

The year of 1906 was singularly free from major explosions in this country but brought with it the greatest mining catastrophe of all times in the Courriere explosion in France, where over a thousand lives were lost. This operation consisted of a number of mines connected by underground workings through which the explosion swept, covering a vast territory. Nearly all the engineers familiar with the workings were lost in the initial explosion which, together with the fact that fires developed at several points, greatly delayed the rescue work and in-

tensified the danger of those conducting it. The great violence of the explosion had eliminated hopes of there being any survivors, but at the end of two weeks a party of thirteen was discovered still alive in an isolated portion of the mine and still another man was found alive at the end of the third week. Remarkable instances of this kind have been observed in many explosions, the freakish actions of which quite often defy scientific explanation. One must have viewed the terrific violence of a typical explosion to understand how incredible it must appear that any one could have survived; and even though they have escaped the force of the explosion there is still the problem of dealing with the asphyxiating black damp (carbon dioxide) or the poisonous white damp (carbon monoxide), the common products of all explosions.

The year following the Courriere disaster was marked by the two greatest explosions in the history of the American coal industry, accompanied by a series of others that brought the year's total up to about the equivalent of the French catastrophe. The bulk of these explosions was concentrated in the single month of December, and they followed one another with a distressing rapidity that left the coal industry dazed. The month opened with an explosion at the Naomi mine in Pennsylvania, costing the lives of thirty-four men. Five days later, on December 6, the Monongah mines in West Virginia gave us our premier disaster with a toll of three hundred and sixty-one lives, followed by the Yolande mine in Alabama with a fatality list of more than seventy, and the third greatest explosion in the country at the Darr mine in Pennsylvania on December 19, in which two hundred and thirty-nine men lost their lives. This was the Dark Month in the history of the coal industry; it caused an anticipatory tremor throughout the country and coal men began to

look askance at one another, wondering where the lightning would strike next.

The Monongah disaster was occasioned by a unique circumstance entirely unprecedented in the annals of the coal industry. From all the evidence adduced it appears undoubtedly to have been initiated by a runaway trip of eighteen mine cars which were smashed to bits at the foot of the slope where it short-circuited an electric connection, the resulting arc igniting the dust created by the wreck. There was mild evidence of the explosion at the mouth of Number 6 mine where the wreck occurred, whereas it was of great violence at the mouth of the adjoining mine Number 8, showing that the explosion acquired increased momentum as it progressed into the latter mine. These mines had some gas, though not sufficient to justify the use of safety lamps. They were, however, comparatively dry and the coal was of a high volatile character that would give it a high flashing power.

This unprecedented series of disasters stimulated thought on the subject of mine explosions and introduced a new spirit of caution into the industry. Operators started a house-cleaning in their mines, adopting various means to eliminate the dust danger. Old and musty mine laws in some of the States were exhumed and revised along drastic lines and a board of prominent European engineers from England, Belgium, and France were invited to prepare a report and recommendations, based on the practice abroad. The net results were gratifying even though the following year did witness two more heavy explosions. The first of these occurred at the Marianan Mine in Pennsylvania and cost one hundred and fifty-four lives; this was a comparatively new operation developed along the most modern lines and commonly referred to as a model mine. The second occurred at the Lick Branch

Mine in West Virginia on December 29, exacting a toll of fifty-one lives and was followed by another in the same mine two weeks later in which sixty-six men were lost.

Mine explosions are still constantly recurring phenomena with us and will doubtless continue so for some time to come, but it is at least gratifying to note that we have passed through more than a decade of constantly increasing production without any disasters in any way approaching those of the period just described if we except two comparatively large explosions in the West in 1923. The principal reason for this is perhaps due more to the general acceptance by the operators of the fact that coal dust will explode and their adoption of precautionary measures. While this theory had been advanced for a good many years and proved on numerous occasions, it had only been accepted in a conditional manner and seldom acted upon where a very material expenditure was required for preventative purposes. Other contributing factors in reducing the danger from this cause were the introduction of safety explosives, helmets for use in mine fires, a generally increased interest in "safety first", and the development of mines on the panel system, which tended to isolate the explosion.

While 1908 marked the closing era of the large mine explosions, the year following brought with it the greatest mine fire in the history of the industry, when two hundred and fifty-eight men lost their lives at the Cherry mine in Illinois. This fire occurred on a Saturday afternoon in November and started from a bale of hay that had been taken down the shaft on its way to the stables. A rescue party made several trips down the main shaft in an endeavor to save the men but only succeeded in losing their own lives through a misunderstanding in the signals to the hoisting engineer. The shafts were then

sealed up and remained so until the following Monday afternoon when the seals were removed and an attempt made to enter the mine. The fire soon got out of control again, however, and it was necessary to replace the seals. A fire engine had in the meantime been brought down from Chicago and some five hundred gallons of water a minute were being pumped into the mine. Temperature conditions appeared favorable to another attempt on Thursday and after a hard struggle, under exceedingly dangerous conditions, an entrance was effected and some bodies recovered on Friday. The fire was fairly well under control by Saturday and the rescue parties were able to work their way farther into the mine where they found twelve men who had barricaded themselves in a place and were still alive.

The U. S. Bureau of Mines compiled a record up to the first part of 1924, showing where two hundred and seventy-five lives had been saved in mine disasters of different kinds by the men barricading themselves off, and the Bureau expressed the opinion that a great many more might have been saved in other explosions and fires had they done likewise. In studying the record of 140 disasters, for instance, it was found that 1,477 men were killed by the violence of the explosion and 1,391 by the deadly afterdamp. It has been frequently noted that men sometimes travel long distances from their working places after an explosion and before they are overcome.

In Table 10 in the appendix we give the fatality rates per thousand men engaged at the mines and the production in short tons per fatality for the years 1907 to 1922 inclusive. Table 11 gives the fatal accidents by causes for the years 1916 to 1921 inclusive. Both of the tables are from records compiled by the U. S. Bureau of Mines.

The fatality rate at mines in this country does not compare favorably with that in the European mines. Thus the rate in Belgium, where the mining conditions are particularly difficult, is seldom much in excess of one for each thousand employees, whereas in this country our rate is usually between four and five per thousand. The wide difference is usually ascribed to American energy and high-pressure methods of operations, together with a characteristic disregard to things of this nature, and if this is the case we are paying a heavy price for our indifference.

Conditions in the British mines are much the same as in Belgium in this respect, the average annual fatality rate for the decade ending in 1922 being 1.15 per thousand employees and 4.92 for each million tons of coal mined. In 1922 the two rates were 0.95 per thousand employees and 4.32 per million tons of coal produced. In comparing these figures with those in this country it should be remembered that the production per employee here is about twice that in England.

An interesting study of the causes and distribution of accidents by occupations at a typical group of mines was described in a recent issue of *Coal Age*. The company operating these mines is making rather unusual efforts to reduce its fatality rate, in pursuance of which idea it has a special mine inspector and has kept the physical condition of the mines up somewhat above the average. Its rate is, consequently, somewhat below the average for the country, being about 3.5 per thousand employees.

The bulk of the accidents is sustained by the miners, about forty per cent. of the total being to men in this class. Brakemen engaged in haulage operations suffer twenty per cent. of the accidents, but since there is a very small number of these as compared with the miners, the propor-

tion of the former is somewhat larger. About ten per cent. of the accidents occur to trackmen and half that number to machinemen and motormen each, the remainder being distributed through the various other occupations with the blacksmith, drivers, ditchmen, watermen, car-repairers, tipple men, and electricians each sustaining one per cent. of the accidents.

Falls of slate are responsible for twenty-seven per cent. of the accidents and falls of coal for nine per cent., making thirty-six per cent. from this cause. Handling material occasions eleven per cent. of the accidents, hand tools six per cent., while five per cent. are due to being run over by cars, and the same number to coupling cars and to collisions, each.

CHAPTER III

Mechanical Equipment

In a previous chapter we have shown the early development of mechanical equipment for use in mining operations, and how completely the progress in the industry as a whole has rested upon the advancement in these lines. No single element in the whole intricate system of the mining industry has had such a direct influence on it as the vast and sweeping improvements in the application of power equipment to the mining of coal. And, curiously enough, the increasing use of steam power in transportation and manufacturing has also opened up the most important market for the product of the mines as well.

There is now over three million horsepower of mechanical energy used in and around the mines of this country. This represents one horsepower for every two hundred and twenty-five tons produced and four horsepower for each man engaged in the industry. Strange as it may seem, the industry purchases thirty per cent. of its power from outside sources of supply and consumes twenty million tons of coal annually in making the rest. The power equipment includes some fifteen thousand steam engines and about fifty thousand electric motors used for various purposes.

Figures such as the above are difficult to visualize in the abstract. One can scarcely picture an array of fifteen thousand steam engines having an average of one hundred

and thirty horsepower each. The economic importance of this power will be better appreciated in terms of the efficiency derived therefrom. In 1890, in the early days of steam power and before the mining machine had come into general use, the production per man engaged in the industry was 2.6 tons per day; in 1900 this had increased to 3.0 tons per day, 3.5 tons in 1910, and 4.2 tons in 1921. Thus we see the progressively increased efficiency attained by the perfection and more general application of power equipment and the end is not yet in sight. Were it not for these improvements of the past, the cost of coal might even now be prohibitive to the poorer classes and with the constantly increasing costs of the future, the engineers will be stimulated in their efforts to invent compensating methods of efficiency.

HOISTING

One of the first and most important applications of steam power in the mining of coal was for hoisting purposes. Hoisting may be divided into two general classes, hoisting through a vertical shaft and hoisting from an inclined slope. In shaft hoisting the loaded mine car is run on to a cage, hoisted to the surface, and dumped automatically, or the car removed from the cage and dumped separately; or the mine car may be dumped into a skip at the shaft bottom and the coal hoisted in this way. In hoisting from a slope the loaded cars are drawn from the mine by means of a wire rope in trips of from five to twenty or more, the empties returning over the same track by gravity and dragging the rope with them to bring up the next trip.

The modern hoisting engine has been perfected to a remarkable degree of excellence as regards reliability, speed, and economy of operation. A typical example of

the steam hoist used at the mines to-day is shown in Figure 30; the sketch at the bottom is an end view, showing the engine cylinders on each side with the two conical drums for the rope between, and the one at the top is a side

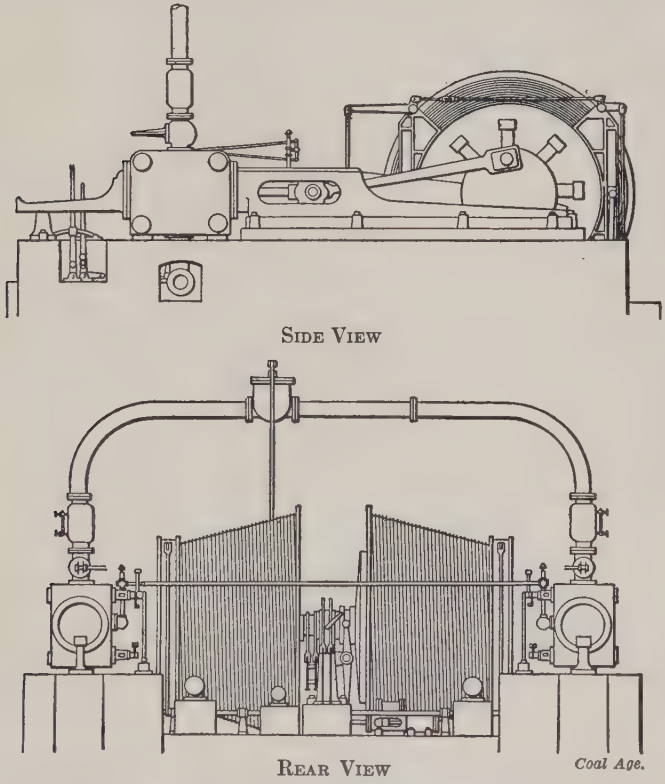


Fig. 30. Side and end view of a typical high-powered corliss-valve steam hoisting engine equipped with conical drums.

view, showing how the engines connect with the drum. This engine is designed for balanced hoisting from a vertical shaft, there being two cages connected by separate wire ropes to the two drums shown in the figure. These ropes are attached to the drums in such a manner

that when the cage is at the bottom of the shaft the rope will be at the smallest end of the drum, and vice versa, the object of this being to assist the engine in starting the load from the bottom; it is obvious that the smaller the drum the lighter the load will be on the engine, and this action is further assisted by the rope on the descending cage which would be at the high point on that drum and consequently exerting the maximum counterbalancing effort to assist the engine in starting the other cage. These drums taper from ten to fourteen feet in diameter so that there would be an appreciable difference in the torsional effort at the two ends.

This engine is designed to make one hundred hoists per hour from a depth of sixteen hundred feet, bringing up two tons per hoist, and it has many refinements that reduce the steam consumption to a minimum and assure perfect control throughout the hoist. The valves are so arranged that the engine will get the maximum steam in starting the load, this being gradually cut down as it attains maximum speed, thus saving the power. The brakes are steam operated, as is also the reversing gear. Coal operators at one time computed the cost of their steam power on the basis of the actual cost of the coal at the mine, but in the approved accounting systems now in use, it is charged at the selling price, and this has resulted in a closer scrutiny of all possible means of saving power.

The electric hoist has also come into considerable favor in the past decade, particularly for use at those mines which purchase their power. Like the substitution of the electric locomotive for animals, the first cost of the electric hoist is still rather excessive, but this is being reduced as they are becoming better perfected and they may, in the course of time, entirely displace the steam hoist.

The hoisting shaft is the bottle neck of the mine, to

which the coal converges from all the different sections, and the capacity of the mine is usually fixed by the dispatch with which it can be handled here. Delay in this quarter is immediately reflected back through the whole mine, and a temporary idleness for repairs may easily result in a loss of several hundred tons in the day's production. The very best efforts of the engineers have been brought to bear on this subject to attain the maximum perfection in speed of operation with the minimum of delays, and almost incredible records have been made in hoisting coal.

We have, for instance, a very remarkable record of 8,220 tons of coal hoisted from a single shaft at an Illinois mine in the year 1922, sufficient to fill 164 railroad cars of fifty tons capacity each. The length of the hoist was six hundred feet, five tons of coal being brought to the surface and dumped at an average rate of seventeen seconds per hoist; after allowing five seconds for dumping at the top and caging the loaded car at the bottom, and another five seconds for starting and accelerating the hoist, this means a maximum hoisting speed of very slightly under a mile a minute. At another Illinois shaft, with a depth of some two hundred and thirty feet, a record of twelve seconds per hoist was maintained for over an hour, the average for the whole shift being 13.6 seconds. The cars at this mine were of small capacity so that the tonnage hoisted was considerably less than that for the other mine, but this was the world's record for the number of hoists up to the year 1923.

Records such as the above could only be realized with the most expert enginemen at the throttle and the strain of handling a powerful engine at these high speeds is such that it is customary to relieve the operator every thirty minutes. To attain a hoisting speed of a mile a minute

with the starting and stopping points only six hundred feet apart requires constant manipulation of the engine, particularly in retarding the hoist to make an easy landing at the top and bottom. This last can only be accomplished by what is termed plugging the engine to slow it down, which means instead of relying on the brakes the engine is reversed and given the required amount of steam to check its enormous momentum.

HAULAGE METHODS

In the chapter on Early Mining Methods we traced the methods of transporting the coal underground from the time it was first carried in baskets up to the advent of the mine car and the pony or horse for drawing it. The horse is still an important factor in mine haulage, though used mostly for auxiliary purposes, but he has been supplemented by so many other methods that it is likely he will disappear from the mines entirely in the near future.

The systems of haulage now employed fall into two general groups, rope and locomotive haulage, each having several subdivisions. In the rope-haulage group we have the engine-plane method, used in slope mining as already mentioned under Hoisting, the tail-rope, endless-rope, and the gravity-plane methods. The locomotives used in mine service are operated by every known power — steam, compressed air, gasoline, and electricity — the last being substantially the most popular method at the present time. In addition there is also the animal haulage already mentioned.

In the animal haulage class the mule has been used more generally in this country than the horse, as he takes to the underground conditions more readily, stands up under the work better, and is not so nervous as the horse.

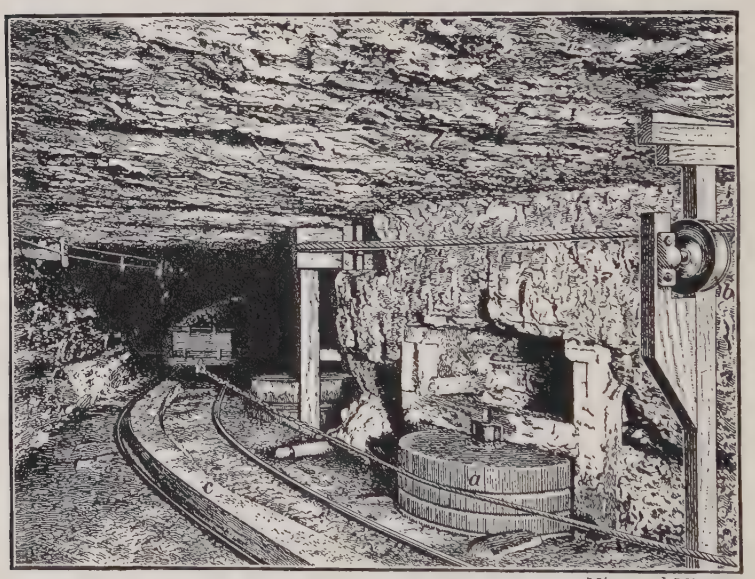
Animals are now used almost exclusively for gathering purposes in the mines; that is, for collecting the individual cars from the rooms and assembling them in trips [1] for the motors. A special type of gathering motor is also used for this purpose, but it has certain inherent disadvantages on work of this kind that has caused many engineers to adhere to the mule and horse.

The life of a mule in mine work varies from five to ten years as a rule, though some mines use them up faster than this because of specially hard and adverse working conditions. The mule becomes remarkably adept in his work, displaying an almost human sagacity in getting about the mine and avoiding the many dangers incident to his precarious life, such as being run down by trips of loaded cars, etc. They have a well-developed sense of their just dues as a rule, responding to kind treatment with their best efforts, but sulking and becoming vicious when abused. In a drift or slope mine the mule is usually stabled outside at night when the distance from his work is not too great, but at shaft mines there is so much difficulty in getting him in and out that stables are provided underground where he stays the year round, with the possible exception of a short season of pasturing during the dull period in midsummer.

The tail-rope and endless-rope haulage systems were used quite extensively in flat seams before the advent of the electric locomotive, but they are now gradually disappearing. In the tail-rope system two ropes are attached to separate drums on an engine, one called the haulage rope and the other the tail rope. The tail rope passes into the mine over a series of rollers, sheave wheels, etc., at one side of the track and around a wheel at the extreme inside end and is then attached to the tail end of the trip

[1] A "trip" in mining parlance is the equivalent of train in the ordinary sense.

of cars. The haulage rope passes in along the center of the track, supported on track rollers about every fifty feet, and is attached to the front end of the trip. As the trip is pulled out by means of the haulage rope it brings the tail rope with it, and when the outside is reached the two ropes are connected to the front and rear ends of the trip



Mines and Minerals.

FIG. 31. View showing a trip of cars being pulled around a curve by the tail rope haulage system.

of empty cars, the motion of the drums on the engine reversed, and the tail rope draws the cars back into the mine, with the haulage rope attached to the end.

This system has been used for hauls up to a mile or more in length and in some respects it has certain advantages over locomotive haulage. However, it involves an amazingly intricate system of rollers and wheels, particularly where angles occur in the haulage road, and the

maintenance cost of these is so heavy that the method has come into disfavor. Figure 31 shows the method adopted for negotiating a curve in the track with this system. The rollers carrying the tail rope are shown at *b*, these being placed about every fifty feet along the haulway and a special guard rail *c*, which prevents the trip from being derailed by the oblique pull of the rope at the curve.

The endless-rope system operates on somewhat the same principle as the tail rope except that only a single rope is required which passes into the mine on the center of one track and out on the center of another. The rope is kept constantly moving at a comparatively slow rate and in the same direction, the loaded cars being attached to the outgoing rope by means of grips and the empty cars to the ingoing rope. Good results have been obtained with both of these systems, but their lack of flexibility, due to the difficulty in negotiating curves, as well as the other objections already mentioned, has caused them to be discarded in favor of the self-contained locomotive unit.

What is believed to be one of the oldest mines on the North American continent, according to an article in *Coal Age* in January, 1924, is equipped with an endless-rope haulage system. This system has been gradually extended from time to time until it has attained the remarkable length of five and one-half miles. The average production of the mine is twelve hundred tons a day and the maximum capacity is around fifteen hundred tons; the maximum tonnage ever produced in a single shift was twenty-four hundred and in a double shift, thirty-three hundred. This mine was opened in 1865 at Glace Bay, C. B., and is now operated by the British Empire Steel Corporation.

The engine-plane haulage system is the simplest and most important application of the rope and hoisting engine to haulage purposes. It is also the only practical method for hoisting where the seams are inclined to any appreciable extent and in such districts it is used extensively. This system contemplates the use of a single rope attached to a hoisting engine at the head of the slope, the loaded cars being drawn from the mine in trips of five to twenty or more, by means of a wire cable, and the empty cars returned by gravity. Some track rollers and sheave wheels are required for the guidance and care of the rope, but the system as a whole is much less intricate, and at the same time more flexible, than any of the other methods of rope haulage. While it is used mostly for main haulage on slopes, it also finds some application for use as auxiliary haulage within the mine. When used as the main haulage on a slope, the engine plane is the controlling factor in fixing the output for the mine, the same as in shaft hoisting, and much that has been said for the latter will apply equally well to the slope mine.

Gravity planes are used where the mine opening is above the tipple or wherever it is necessary to lower the loaded cars and raise the empties. As its name signifies it is operated by force of gravity, the excess weight of the loaded trip descending being more than adequate to raise the empty cars. The ascending and descending trips move simultaneously, so that two tracks are necessary, but on long planes this is overcome by using an ingenious system of three rails, the center one of which is utilized by both trips, though it is still necessary to provide two distinct and separate tracks where the trips pass each other at the center of the plane. The operation of a gravity plane is rather slow and cumbersome as compared with the other methods practiced to-day, and as

its use is limited to certain specific conditions, it has not found a very wide application.

Locomotives of various types are now used to handle the bulk of the coal underground. In general all locomotives have certain common advantages and disadvantages as compared with other methods of hauling. The first cost of any system of locomotive haulage is substantially greater than that of animal haulage. The machines themselves cost more than mules or horses and to this must be added the cost of plant, trolley wires, etc. It is also necessary to provide a substantially better track in mines equipped with mechanical haulage so that the difference between this and a lighter form of track may be properly charged to the cost of such an installation. Locomotives are also limited as to the grades they can be economically operated on, in which respect the rope haulage has a distinct advantage over them.

On the other hand, the mine locomotive has important advantages over other systems of haulage in flat seams that more than compensate for these disadvantages in average conditions of operations. As compared with animal haulage the locomotive handles appreciably heavier loads at much higher speeds so that for main haulage purposes in large mines it not only makes a larger production possible but reduces the costs to a fraction of that with animal haulage. For lighter service such as gathering the individual cars from the working places and assembling them in trips for the main haulage, opinions vary as to which method is the more economical and this would depend largely on local conditions.

As compared with rope haulage, the locomotive is more flexible, negotiating curves with comparative ease, and is unlimited in the length of haul. It does not necessitate the maintenance of the elaborate system of rollers, wheels,

etc., that are an essential part of any rope system and eliminates the possibility of a breakdown through the failure of any of these numerous agencies, thus tending to greater reliability.

The steam locomotive was the first to make its appearance in the mining regions, being used quite extensively in the anthracite districts and finding some application in the bituminous fields of Virginia and West Virginia also. There is an obvious disadvantage to the use of a steam engine in mine service which will be at once apparent to any one who has endeavored to survive a trip through a railroad tunnel on the observation platform of a passenger train. The obnoxious fumes and smoke limited the range of activity of this type of locomotive to portions of the mine where the ventilating currents could dispose of these readily, which was generally close to the surface. They were also liable to cause a fire in the mine, because of the large amount of combustible material along the haulways, and for this reason were very dangerous. The steam locomotive has practically disappeared from mine service, though it is still used for hauling on the surface.

The compressed-air locomotive, which, as its name signifies, is operated by air compressed to high pressures in the same manner as the steam locomotive, was introduced to overcome the objectionable features of the latter. This type of locomotive was in considerable favor before the perfection of the electric locomotive and is still used to a limited extent, particularly in gaseous mines. It is the only type of locomotive that is regarded as entirely safe for use in mines having large volumes of gas, the dangers of which it tends to partially alleviate by dispersing the gas with the exhaust from the engine. These locomotives are rather heavy and cumbersome due to

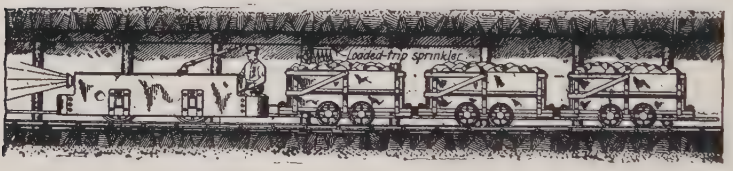
the fact that they have to carry a large supply of air compressed to around one thousand pounds per square inch, and their range of operation is limited since they cannot work too far from their source of air supply.

The gasoline locomotive made its appearence early in the twentieth century along with the automobile, but it has not achieved to the popularity for hauling coal that the motor car has in its sphere. This locomotive has certain inherent advantages over other types that would seem to justify a greater popularity than it has received, and it will probably come in for more consideration with further improvements in the gas engine. It has the maximum flexibility of action and is independent of trolley wires, track bonding, and does not require a heavy initial expenditure for a power plant, wiring, etc. There is also the freedom from the possibility of damage from overloading as in the electric locomotive, where this may result in a burnt-out motor. One disadvantage of this locomotive is the emission of the noxious gases from the exhaust, though this is not harmful where the ventilation is even moderately good.

The electric locomotive is substantially the most important means of hauling coal underground to-day. The first locomotive of this type was put in operation in the anthracite regions about 1887 and the second in 1889, this last remaining in service for more than a quarter of a century in spite of the many improvements and refinements introduced during this time. A modern type of electric locomotive is shown in Figure 32, and it is remarkably efficient and thoroughly reliable even under the rough usage it is subjected to in the mines. This, and the fact that electricity has now become an almost indispensable adjunct to every mine for lighting and for operating auxiliary machinery such as mining machines, pumps, tipple

machinery, ventilating fans, etc., has served to place the electric locomotive in a dominant position for purposes of mine haulage.

The electric locomotives are of two general types, the storage battery and the trolley motors, and sometimes a combination of these is used which has the advantages of both. Of these types, the trolley motor is by far the most popular. These locomotives are manufactured for mine service in standard weights varying from two or three tons up to as much as thirty tons, though they rarely exceed twenty tons, and then only in mines having exceptionally large cars. The heavier types are used on the



Coal Age.

FIG. 32. An underground electric trolley locomotive drawing a trip of mine cars.

main haulways where they pick up long trains or trips of cars that have been assembled by the lighter machines and take them out to the tipple, returning with equally large trips of empty cars. These locomotives operate at high speeds over excellent, well-graded tracks and, considered on a ton-mile basis, represent about the maximum achievement in economy for mine haulage.

Locomotives working on gathering service have more difficult conditions to contend with. Their sphere of operations is limited to new sections of the mine, where the tracks are of a more or less temporary nature and haulage conditions generally adverse. Their activities are also confined to picking up individual loaded cars and replacing these with empties, which involves considerable switch-

ing, and they are frequently off the track and in trouble of various kinds. There is a difference of opinion as to the economy of locomotives on this class of work, and many engineers prefer animals.

It is not the general practice to extend the trolley wires into each room in the mine, since these are of a temporary character that scarcely justifies the expense, so that the trolley locomotive is usually eliminated from consideration for gathering purposes. In some mines where conditions are favorable and union rules permit, the miner is required to push his car in and out of the room. The storage battery locomotive finds its principal application on work of this kind as it is, of course, entirely independent of the trolley wire. The combination trolley and storage-battery type of locomotive gives excellent results too, since it can leave the trolley line at will and on its return resume the use of the trolley and be recharging the battery at the same time.

Trolley locomotives are sometimes fitted with special apparatus that enables them to place cars in the rooms. In one of these methods a cable is hung on the trolley wire which supplies the motor with power wherever it may go and in another the locomotive is equipped with a reel and a wire rope, the former being operated by power from the locomotive and drawing the car from the room by means of the rope. Both of these methods are used quite extensively and with generally good results.

The U. S. Bureau of Mines prepared an analysis of the different kinds of haulage used in the mines of this country for the period 1919 to 1921 which shows the popularity and rate of increase or decrease of the various types. The number of mines investigated was 6,136 in 1919 and 7,088 in 1921 and the results were as follows:

The use of animal haulage increased from 4,458 mines

to 5,064, but as no distinction was made between the size of the mines and since the smaller mines would naturally incline to plants involving less expensive initial cost, the comparison is not satisfactory from the point of actual tonnage handled. Also a great many mines using mechanical methods for main haulage would have installed animals for auxiliary or gathering purposes.

Rope haulage increased from 996 mines to 1,066, representing perhaps the increased number of slope mines using engine planes after making some allowance for other mines still using some of the more obsolete tail and endless-rope methods which were abandoned during this interval.

Compressed air declined in use from 112 to 84 mines, bearing out the conclusions drawn in the preceding discussion concerning this method of haulage.

Storage-battery electric locomotives showed a very substantial increase in use from 437 mines to 693, though here again it is likely that many of these were installed as auxiliary haulage at mines where trolley locomotives were used for the main haulage.

Gasoline locomotives showed a healthy increase from 226 to 271 mines, and the steam locomotive a moderate increase of from 497 to 528, this last, however, being one less than was used in 1920.

The use of electric trolley locomotives increased from 2,848 mines to 3,274, and if a comparison were available on the basis of the tonnage handled the increase would doubtless be more striking.

MINE TRACKS

The arrangement and construction of the underground tracks to handle tonnages on the scale contemplated in the modern mines of to-day is a matter that requires the most careful consideration. Haulage is necessarily con-

fined within definite limitations by the available entries, and the system of operation must be very carefully worked out to avoid congestion, confusion, collisions, and waste effort. Definite running schedules, similar to those used on the railroads, are generally adopted for the main haulways and the whole operating scheme of the mine is based on this schedule. Loaded trips of a certain number of cars arriving at definite intervals at the tipple would be arranged for and the necessary equipment provided in the way of dumps, screens, etc., together with the required number of men to handle these without delay.

In the mine the main haulage would be scheduled to provide certain definite allotments of cars to each of the secondary haulage systems so that these would not be delayed waiting for empty cars or have their limited switching capacity congested. The secondary haulage systems must, in turn, provide the main haulage with a definite number of loaded cars so as to occasion no delay to this important artery which would be reflected in delays and waiting throughout the whole mine system. The secondary system must also keep its switch on the main haulage free from empties in order to avoid congestion there and provide prompt distribution of these to the working places so that the miners will not be delayed in their work of loading the cars. Other conditions being equal, the mine providing the most cars for its miners to load will also have a better labor supply and be in a position to be more discriminating in the selection of its men.

It will thus be seen that the haulage system of a large capacity mine is a very intricate one involving several interlocking operations entirely dependent on each other. Delays in the gathering, main haulage, or at the tipple will very quickly cause a congestion and consequent further delays throughout the whole or major portion of the

entire system, that may easily result in a loss of several hundred tons in the day's production and with no reduction in the overhead. The mine tracks have reached a high degree of excellence, comparable in many cases with some of the second or third-rate railroads, but their construction and maintenance involve special difficulties that surface lines do not have to contend with. The presence of water creates a more or less unstable foundation that results in a poor roadbed in which defects occur that are not readily discernible in the darkness of the mine, until a trip has been wrecked.

Coal Age.

FIG. 33. Track layout for a typical secondary motor haulage system.

A typical system of gathering loads for the main haulage at a moderate size mine is shown in Figure 33. The main haulage locomotive operates on the Main Line indicated in the sketch, from which it crosses over and places its large trip of empty cars in the entry *E*, specially designed for this purpose, at the same time picking up the loaded trip from the track shown. Two gathering locomotives operate from this parting, one handling the first and second North Entries to the west and the other the third and fourth North Entries to the east. The one working to the east backs in on the switch *E* and picks up ten to twenty empty cars which it draws to the west until the

last car clears the switch *A*. It then backs into the first or second North Entry, whichever is in need of empty cars, pushing one into each room where it is required. When all the empties have been placed in that entry, the motor crosses over into the other entry through the switch shown on the sketch, where it picks up the loaded cars from the rooms on its way out, placing them on the loaded track for the main haulage motor. It will be observed that this system provides for a continuous cycle of effective work, the locomotive never running without a trip of cars. The gathering motor to the east would operate in the same way and each of these motors under average conditions would handle about two hundred cars a day.

In discussing the systems of mining, mention has already been made of the importance of laying out the mine so that the coal would move generally in a downhill direction toward the main opening or shaft. In nearly all fields there is a major inclination or dip of the seam which can be readily determined in prospecting and it is of the utmost importance that full consideration be taken of this to assure economy in the haulage. As an example, the ideal grade for a locomotive haulage system is about one per cent. in favor of the loaded trips, varying somewhat according to the condition of the track, type of mine car used, etc. On this grade, a mine locomotive can pull about the same number of empties up as it can take loads down, so that we have a perfectly balanced system. Should the mine be laid out in such a manner that it would be necessary to haul the loaded cars up and the empties down, the locomotive would have to make about three times the number of trips out with the loaded cars as would be required for taking the empties in, the cost of which would be prohibitive on an important haulway.

On a main haulage system of a large mine the track will be laid with the greatest care as to alignment and grade, in order to permit of high speeds in the movement of the coal. Curves of large radius will be used, profiles of the track made and minor irregularities in the grade eliminated where this will tend to increase the capacity of the locomotive. Tracks are laid with very heavy sections of standard railroad rails, usually around fifty or sixty pounds on main haulage, though considerably smaller on cross entries and in the rooms, sixteen-pound iron being commonly used in the latter. While the practice varies with different companies, depending somewhat on their financial condition, the larger companies are usually insistent upon the best type of track conditions.

MINE CARS

There is no other part of the mine equipment subjected to the severe usage that falls to the lot of the mine car. At the working face it is traveling over poorly ballasted, uneven tracks which tend to develop unexpected strains and stresses. It is frequently off the track, dragged over the ties, and mauled and manhandled in every way that an exasperated motorman with a powerful locomotive can invent. On the main haulage, track conditions are more favorable but the cars must travel at exceedingly high rates of speed, are subjected to terrific jars in starting and stopping the long trains, and finally it can be accepted as axiomatic that a certain number of violent wrecks are an inevitable accompaniment of the year's run at any mine.

The efforts of the mine-car designers to develop a car that would meet these varying conditions, and at the same time have a large capacity and be easy running, have resulted in an amazing variety of designs, one manu-

facturer alone stating that he has made over two thousand different types. In no other branch of the mining industry is there such a wide difference in practice as in the use of mine cars. There are, however, certain fundamental principles that all mine cars must conform to, though these will vary with the thickness and general character of the seam in which they are to be used.

The influence of the height of the coal on the shape and size of the car is shown in Figure 34. It must be remembered in considering this question that for reasons of econ-

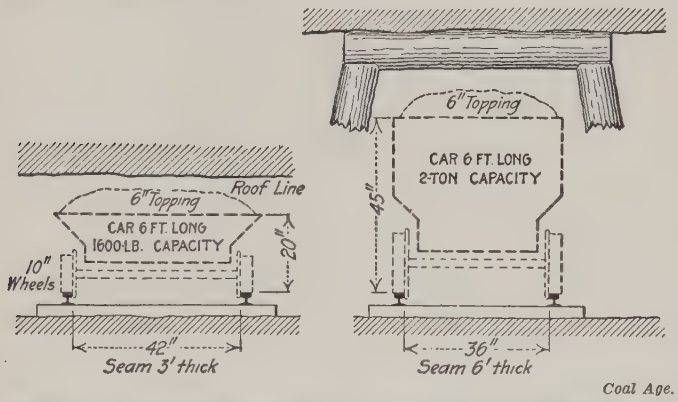


FIG. 34. Characteristic sections of mine cars for low and high seams.

omy, mining operations in general are confined strictly to the limits of the coal seam; where the seam is so thin that it is necessary to take down a part of the overlying rock and remove this from the mine it will be at once apparent that the cost of this would be prohibitive except under some unusual conditions. This sketch shows ideal sections of cars for both low and average or high seams.

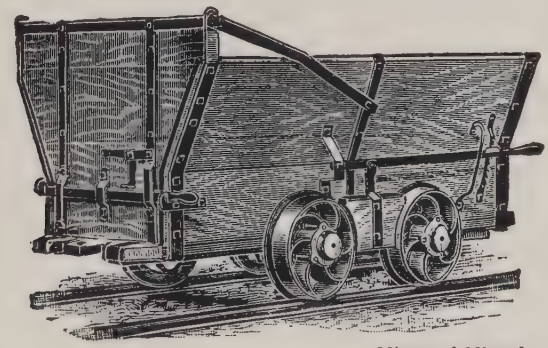
It will be noted in the car designed for the three-foot seam that an attempt has been made to increase the capacity by increasing the width, whereas the other car is considerably higher but narrower, and has a wheel of

larger diameter. The narrow track gauge and larger wheel will give an easier running car, which would be an important factor with one of a large capacity such as this, but less important with the smaller car than the question of securing additional capacity. It is also desirable to drive the haulways in the thicker seams as narrow as possible, since the coal has a tendency to disintegrate and break off the sides in the course of time; this condition may develop an exceedingly bad situation where the coal is specially friable and the seams thick.

As will be observed in the sketch, the bodies of the cars are flared out sharply at the top of the wheels in order to increase the capacity as much as possible. The cars are commonly made around six feet in length and the wheel base is seldom over forty-two inches in length and sometimes as small as eighteen inches, so that they will have no difficulty in negotiating sharp curves; this also leaves a considerable overhang at each end which facilitates replacing them on the track when they are off. Cars are generally made of wood on an iron and steel frame, but all-steel cars were introduced some years ago and are preferred by some engineers. The wood car is still the most popular, however, owing to its lower first cost, ease of repairs, and greater flexibility over the uneven mine tracks. A frame car may be smashed to bits in a wreck and the mine blacksmith will still be able to salvage most of the iron work and rebuild the car with some new boards, where special machinery and expert workmen are required to restore a badly damaged steel car.

An example of the typical mine car is shown in Figure 35. The high end is a door arrangement, the hinges of which are formed by the two iron bands passing over the round iron rod at the top and down on the inside of the car, the bottom end of the door being held closed by means

of the latch shown in the sketch. When the car arrives on the automatic dump this latch is raised, thus allowing the coal to run out freely when the car is tilted up at an angle. It will be observed that substantial bumpers covered with steel plates are provided to take up the heavy shocks of handling the cars in mine service. This car is also equipped with brakes, the operation of which will be evident from the sketch; these are convenient at times but are not essential and only present another means by which the car can get out of order. A great



Mines and Minerals.

FIG. 35. The typical wooden mine car used in the mines to-day.

deal of attention has been given to the production of a rugged and easy-running wheel for the mine cars and there are quite a number of patent wheels in use embodying the roller and ball-bearing principles and with very excellent provisions for keeping the bearings well lubricated. These refinements add somewhat to the cost but they will sometimes double the hauling capacity of the locomotive and are a good investment.

MINE DRAINAGE

The great difficulties experienced in draining the mines in the early days of the industry have already been touched

upon, and the important part which the development in mechanical lines did to relieve this situation. The reader will better appreciate this when he knows that some fourteen tons of water are handled from the anthracite mines for every ton of coal produced. The anthracite mines contend with substantially the largest volumes of water of any in the country, but the problem of drainage is a more or less serious one at all mines and is becoming steadily more important as the mines extend to greater depths.

We have already mentioned on several occasions the importance of making the initial mine opening at as low a point as possible in the field it is proposed to work, for economy in both haulage and drainage. Where it has been practicable to locate the mine at this low point, the drainage problem will resolve itself into one of keeping the ditches clear, or in the case of a shaft mine, conducting all of the water to the shaft bottom and then to the surface with a single pumping operation. This is the simplest form of mine drainage we have and to this might be added the construction of the long drainage tunnels which is being resorted to in the anthracite regions where conditions are favorable.

Drainage systems at large mines making considerable water are often complicated and involve a number of different methods of procedure. The attempt is first made to concentrate the main volume of the water at some convenient point for pumping to the surface and install there a permanent pumping station having sufficient capacity to handle the water from the whole mine, with some reserve for emergencies. Where a mine is making large quantities of water, this main pumping station will be equipped with a pump having every conceivable device for producing the maximum efficiency with the minimum consumption of power, some of the mine pump-

ing stations representing the greatest refinement in design there is. An example of one of the larger installations of this kind in the anthracite regions is shown in Figure 36, this being one of a duplicate unit installed. Each unit weighs seventy-five tons and is designed to handle three thousand gallons of water per minute, lifting it six hundred feet to the surface. This is a compound, duplex pump with cylinders twenty-five and forty-four inches in diameter and having a four-foot stroke, the principal over-all dimensions being given in the sketch. The power end is at the right and the water end at the left, the latter being lined throughout with wood and bronze to avoid corrosion from the acidulous mine water.

The centrifugal pump has come into considerable prominence in recent years and is now an important rival of the plunger type of pump above described. As its name signifies it has a rotary motion which makes it particularly adaptable for use with electrically driven machinery, and per unit of size or weight it will handle about four times the volume of water that the plunger pump does, so that its first cost is considerably lower and it is at the same time more compact and mobile, all of which are factors of importance for mine service. The centrifugal is, however, somewhat more temperamental in its action, requiring expert attention in case of trouble, and it loses its efficiency very rapidly when working under conditions as to head and capacity other than that for which it is specifically designed.

A cross section of a typical centrifugal pump is shown in Figure 37. The pump operates somewhat on the principle of the mine fan already described, developing pressure by means of one or more impellers operating at a high speed and throwing the water against a casing around the periphery of the impellers, from which it is conducted to

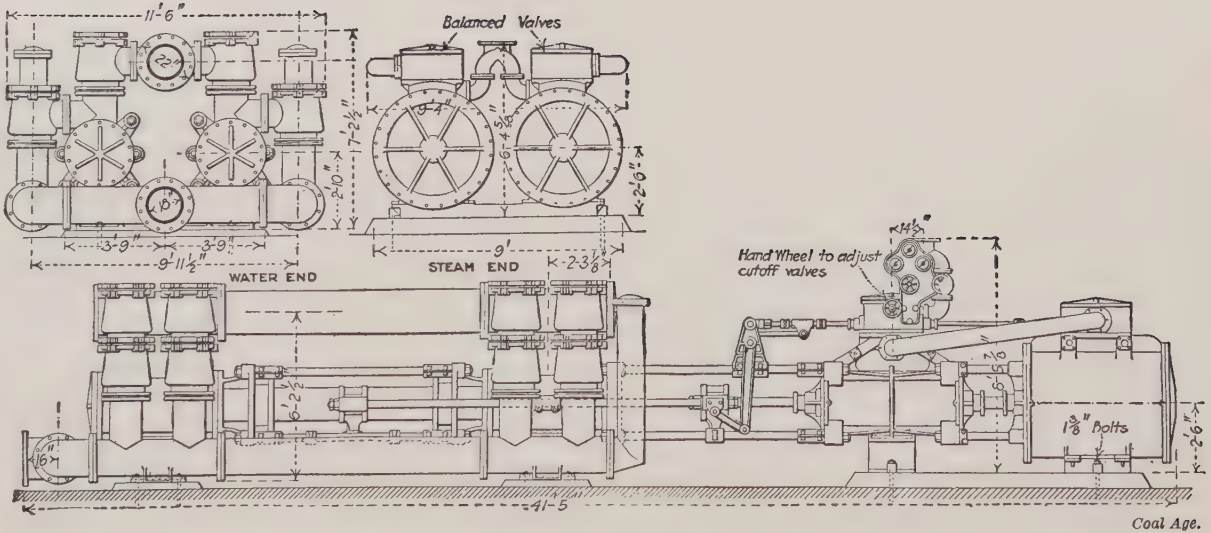
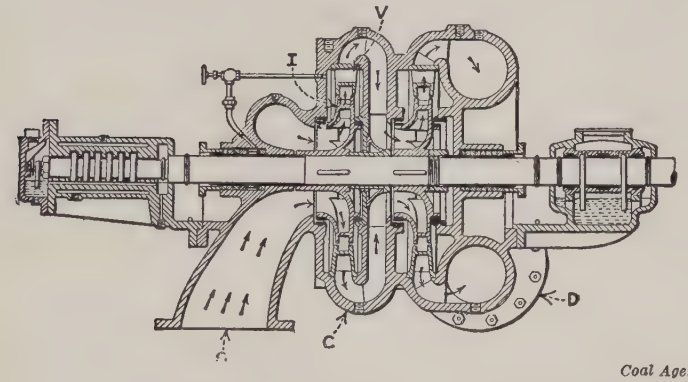


FIG. 36. Side and end views of a compound duplex steam pump designed to handle 3,000 gal. of water per minute through a 600 ft. head.

the discharge pipe. The water enters at *S* and is picked by the impellers *I*, from which it is discharged by means of the diffusion vanes *V*, into the outer casing *C*, and so on through the second impeller and out the discharge pipe *D*. Each impeller increases the velocity or pressure of the water so that the number of impellers used will depend on the height to which it is desired to lift the water. Pumps of this kind have been successfully used for heads up to one thousand feet.

A deep and very wet mine will also have supplementary drainage systems feeding into the main pumping station,



Coal Age.

FIG. 37. Cross section of a two-stage turbine or centrifugal pump.

which will vary in size and importance from the very smallest type of portable pump to installations approaching the size of the main station itself. In flat seams minor irregularities in the bottom will create low places or swamps, as they are commonly termed, which will be drained by ditches if possible; where this is not practicable a small portable pump will be installed until relief can be obtained in some other direction. A very large mine will frequently have a dozen or more supplementary drainage systems requiring more or less constant attention.

A mine spreading over a square mile or more will sometimes have workings approaching close to the surface, affording an opportunity to pump the water out through a drill hole and thus eliminate a considerable amount of underground pipe. The engineers are constantly on the lookout for such natural advantages that will tend to reduce costs.

Other methods of draining the mines are sometimes resorted to as, for instance, a reversion to the old-time methods of hoisting water is being practiced in the anthracite regions to some extent. The regular mine hoist is used for this purpose with a large self-filling tank and very economical results have been obtained. One advantage of this method is that there is no danger of the pumping equipment being submerged by an unexpected inflow of water, a possibility that must be kept in mind with the usual type of pumping plant. The siphon is also resorted to in the mines, when conditions favorable to its use arise.

MINING MACHINES

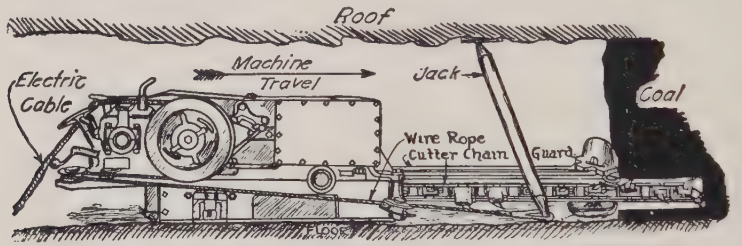
The work of the mining machine has already been touched upon in the section on Digging the Coal. The mining machine effects a very important saving to the operator when working under favorable conditions and may even be the determining factor in putting the mine on a profitable basis. As an example, in a mine where the rate for hand mining was, say, one dollar per ton, the labor cost for machine mining would be around sixty-five cents, to which would have to be added the cost of the power and some minor items such as cost of sharpening bits, repairs and depreciation of the machine, etc., amounting in all to perhaps less than ten cents per ton. American operators are very much alive to the economy of ma-

chine mining and the bulk of the coal is now produced by this method, as will be seen by reference to Table 12 in the appendix. The rapid advance in wages during the war stimulated increased interest in machines and they are now found in every district where conditions are at all favorable to their use.

Mining machines began to come into general use about 1880, two distinct types having been evolved at that time, the puncher and chain machines. The puncher machine operates by compressed air in the same manner as the steam engine, the piston being directly connected to a heavy bit which digs into the coal. The action is not unlike that of hand mining, the strokes, of course, being more powerful, better sustained, and delivered at almost incredible speed. The puncher has two advantages over the chain type of machine, a lower first cost and a capacity to cut seams that could not be handled by a chain machine.

The cost of the puncher machine varies from one tenth to one quarter that of the chain machine, but, on the other hand, the cost of the pipe lines necessary to convey the compressed air would be substantially more than for the electric wires to operate the chain machine, and particularly so since these wires would probably be a necessary adjunct to the haulage system and not properly chargeable to the mining machines in any event. The one distinct advantage of the puncher machine is that it can handle certain types of cutting where the coal is impregnated with hard sulphur balls that the chain machine would not be able to cope with, though these conditions are the exception rather than the rule. The puncher is much slower than the chain machine and this, together with the lack of flexibility in the system of power transmission, has caused it to lose favor except for special purposes.

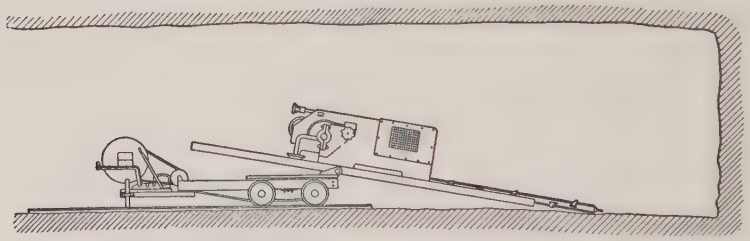
The chain machine, shown in Figures 38, 39, and 40, makes its cut by means of a series of bits attached to an endless chain which moves at a fairly rapid rate. There are two general types of chain machines, the breast and



Goodman Mfg. Co.

FIG. 38. Shortwall mining machine starting the initial or sumping cut.

the continuous-cutter machines, the method of operating the latter being shown in Figure 40, which shows the machine at work at the face of a room. The machine enters the room on the track under its own power, as shown in Figure 39, to the end of the track, where it is slid off the truck and into the right-hand corner of the



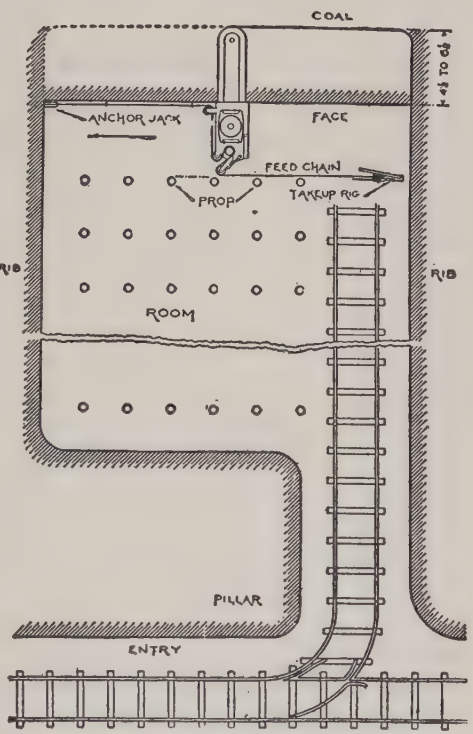
Jeffrey Mfg. Co.

FIG. 39. Shortwall mining machine unloading from self-propelled truck preparatory to making a cut.

room, where it makes its initial cut into the full length of the cutter bar. An anchor is provided in the left-hand corner of the room and another on the right-hand side and to the rear of the machine, to which a feed chain is attached connected with the machine as shown in

Figure 40. By means of this feed chain the machine now propels itself along the face of the room, making a continuous undercut the entire breadth in one operation.

The breast machine makes its first cut in the same manner as the continuous cutter, then withdraws and is jacked over in front of the next part to be cut and so on across the face of the room in a series of operations which, of course, involve considerably more time than with the continuous cutter. Both of these machines work at remarkably high rates of speed, however, the breast machine making its cut six feet deep in four to five minutes under average conditions, though they are heavy and cumbersome to handle and considerable time is lost in moving from place to place.



Trans., Am. Inst. of Min. & Met. Engineers.

FIG. 40. Room plan showing shortwall mining machine making continuous cut across the face.

The cutting bars are made in lengths of from four and one half to twelve feet, though ten feet is about the maximum that has ever been successfully used, and they are more generally six to eight feet. The widths vary from

thirty-nine to forty-four inches, the narrower sizes being used where the cutting conditions are more difficult. The teeth are set in the chain around the edge of the bar at regular intervals, but at varying angles, from three to nine different positions being used, depending on the character of the coal. These bits are subjected to exceedingly hard usage and under particularly bad conditions it may be necessary to replace them several times in a single day's run.

The U. S. Bureau of Mines compiled an interesting analysis of the number and kinds of mining machines in use for the period 1919 to 1921 that shows the relative importance of the different types and their rate of increase and decrease. Operations using hand-mining methods increased from 3,134 to 3,332, while those using electric machines increased from 2,920 to 3,607 and the use of compressed-air machines declined from 332 mines to 288. No distinction was apparently made in the size of the mines investigated and as the smaller mines would be less apt to undertake the heavy initial cost of installing machines, a comparison on a tonnage basis would be much more favorable to the electric machines than is here indicated. The figures show, however, the trend of conditions as previously outlined, the gradual disappearance of the compressed-air machine and the rapid increase in the use of the electric machines which has been greatly stimulated by the spectacular rise in labor costs of the past several years.

The total number of machines of all kinds in use in this country has increased over a hundred per cent. in the past decade and a half. In 1905 there were only 9,184, which increased to 16,507 in 1914 and to 19,618 in 1921. The decline in the percentage of increase for the last period would seem to indicate that the saturation point in the

use of machines was being reached, but when the operators have had time to get their methods fully organized to meet the new conditions created by the existing high wage scales, we shall probably see this percentage of increase on the ascendancy again.

MACHINERY OF THE FUTURE

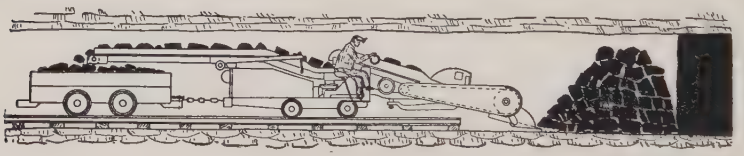
We have shown in the preceding discussions how the development of mechanical devices has supplanted the use of man power and made it possible to work seams at greater depths than was previously the case. There is still, however, an enormous amount of brute labor attached to the mining of coal, perhaps two thirds of the work underground being confined to the task of hand shoveling the coal from the mine floor into the car. The civil engineer of to-day would not contemplate the possibility of moving a few hundred tons of dirt without the aid of machinery; what then can be said of an industry that hand shovels seven hundred million tons of coal a year?

The coal engineer has been keenly alive to this lack of efficiency as measured by present-day standards in other lines and has been striving for a remedy which is now making its appearance in the form of an underground loading machine, the principle of which is shown in Figure 41. There are a number of these machines now in successful operation which are more or less mechanically perfect, but certain technical difficulties have been encountered in working out a system of mining that will make it possible for the machines to work at their maximum efficiency. These problems will undoubtedly be solved in the course of time and their solution will about double the production per man engaged in the coal industry.

The loader shown in Figure 41 is known as the Myers-

Whaley shoveling machine. It has an automatic shovel thirty-four inches wide which picks up the coal and throws it back on a conveyor belt with much the same motion used in hand shoveling. This shovel is mounted on the forward end of a swinging jib so that the operator can swing it to either side, cleaning up a total width of twenty feet without moving. The coal passes from the front conveyor on to another at the rear which takes it to the mine car. The jib and rear conveyor are supported by a main frame section which travels on the mine tracks.

The machine is operated by one man and is adapted for use in all the usual systems of mining. It is self-propelling



Myers-Whaley Co.

FIG. 41. Sketch showing method of operating the underground loading machine.

and can be readily moved from one place to another under its own power. The rear conveyor can be swung latterly so as to load in cars behind the machine or on parallel tracks. There is an adjustment on the jib by means of which the shovel can work above or below the track level. The machine does not require a smooth floor to work on since it can dig into the material and make its own bottom. Its maximum loading capacity is nearly two tons of coal a minute.

A more difficult problem will be the one of working out a method for the combined mining and loading of the coal, which is already being experimented with extensively, with encouraging results. These successive steps will suggest to the reader the ideal towards which the industry is striving — the mechanical extraction and transporta-

tion of coal from the working face to the railroad car on the surface with human agencies confined to installing, repairing, and directing the machinery. These are too revolutionary ideas to have received much consideration at this time, but it is worthy of comment to note that a well-known British scientist has suggested an even more startling innovation by contemplating burning the coal *in situ* as it lies in the ground and thus generating power which would be sent to the points of consumption. It is difficult to believe that the future holds possibilities of improvements on the scale that has been maintained in the past century, but the invention of a successful method representing such a wide departure from the existing practice as the above would make our present methods appear even more crude than we now regard those of our predecessors.

The engineers of the U. S. Coal Commission made a very exhaustive study of the application of the underground loading machine in the bituminous mines and the comparative cost of mining by this method and with hand loading. The Commission found that these loading machines effected a saving of about thirty per cent. on the average and it was figured that when half of the bituminous mines in the country had been equipped with machines there would be an annual saving in the cost of production of more than two hundred million dollars. The introduction of these machines has been somewhat handicapped by a passive resistance on the part of the unions, as is indicated by the fact that of the two hundred in use in 1923 about half of these were in West Virginia. The Commission's engineers were able to make a rather accurate comparison of the difference in the cost between machine and hand loading by studying conditions at a mine that had recently been converted to the use of the

former method. This comparison is of special interest because of the fact that it was made under identical physical conditions of operation, in contradistinction to tests that might be conducted in separate mines. Under the hand-loading conditions 118 men were employed underground in producing 733 tons per day as compared with 73 men producing 814 tons with the machine loading. The average production per man employed underground was thus raised from 6.2 tons under the hand-loading conditions to 11.2 tons with machine loading. Some improvement might also be expected for the machine loader when the organization is better perfected and in a mine laid out specially for work of this kind. The indications are that the machine loader is opening up a new era in coal mining that will mark another important forward step in the method of extracting coal.

CHAPTER IV

Preparation of Coal

The great variety of uses to which coal is put has resulted in the development of an almost equally great variety in methods of preparing it for the consumer. Refinement in the methods of burning coal, in order to realize the maximum efficiency, has resulted in a demand for all sizes ranging from an impalpable dust, as used in power plants operating with powdered coal, to the large lump coal used by the domestic consumer. There is also the problem of cleaning the coal. As will be noted in the section on Geological Considerations, nearly all seams of coal have interstratified bands of foreign material, most of which contain more or less carbonaceous matter. Where these bands are of sufficient importance to make any appreciable difference in the ash content of the seam as a whole, it becomes necessary to clean the coal by washing or hand picking. This may also be done with a comparatively clean seam where exceptional purity is demanded for some special purpose, as for instance in the manufacture of metallurgical coke.

Preparation of the coal begins at the working face and may even have an influence on the system of mining used, certain methods of procedure giving greater or less percentages of lump and fine coal. Where a mine is producing coal for domestic purposes only the system that will effect the greatest recovery of lump coal must be adopted even though it involve additional expense in

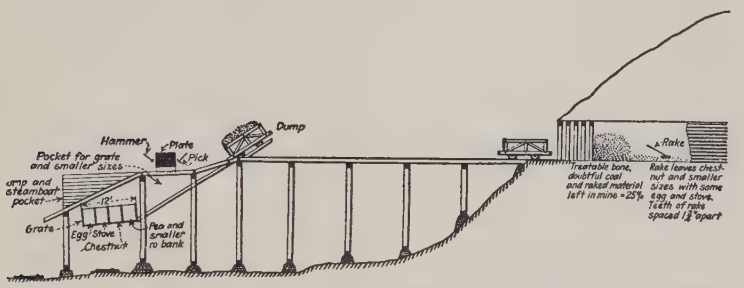
operation. Where certain well-defined partings occur in the seam it devolves upon the miner to separate these from the coal when loading it; these partings are sometimes easily distinguished from the coal and at others resemble it very closely, even occasionally containing a large percentage of carbonaceous matter and under these latter conditions they are very difficult to distinguish from the coal in the semi-darkness of the mine workings. Other conditions also have a bearing on the cleanness of the coal; for instance, when a mine starts drawing the pillars a certain amount of the accumulated refuse of the previous mining becomes mixed in with the coal as it is loaded, so that pillar coal is commonly less pure than that obtained in the original mining.

The anthracite miners were the first to take up the problem of preparing the coal for the consumer, the difficulties in burning it, as already pointed out, making it necessary to provide a certain amount of crude grading of the different sizes almost from the start. The character of the seams is also such that a very large proportion of refuse becomes mixed with the coal in the mining operations so that these conditions have forced the anthracite operators into an intensive study of the question of preparation from the very inception of mining operations. The anthracite practice in preparing and sizing coal is, therefore, far superior to that in the bituminous industry where it has come in for comparatively little consideration as yet.

The first method of preparing anthracite coal, as reconstructed in a paper in the *Transactions* of the American Institute of Mining Engineers from testimony in the Royalty Trial, is shown in Figure 42. The rapid advancement in this branch of the coal industry will be observed by contrasting this method with that of the modern

anthracite breaker shown in Figure 44. This crude form of preparing the coal was introduced about 1830, previous to which time the only preparation used consisted of leaving the finer sizes in the mine, these being regarded as worthless.

In this method the coal was first raked in the mine and the larger sizes taken out and dumped on a cast-iron plate having perforations that would allow the egg, stove, and chestnut coal to pass through. Lumps too large to pass through were broken by hand with a pick and hammer, to the approximate size of lump and steamboat and


Hammer
Plate
Pick
Dump
Rake
Pocket for grate and smaller sizes
Lump and steamboat pocket
12'
Grate
Egg Stove Chestnut
Pea and smaller to bank
Treatable bone, doubtful coal and raked material left in mine = 25%
Rake leaves chestnut and smaller sizes with some egg and stove. Teeth of rake spaced 1¼" apart

Trans., Am. Inst. of Min. & Met. Engineers.

FIG. 42. Early methods of dumping and cleaning anthracite coal.

shoveled into the pocket designated for these in the figure. The part passing through the plate screen entered a revolving screen, where it was separated into the sizes indicated. No power was used, the revolving screen being turned by hand and the whole operation being done by manual labor. The description of this method unfortunately leaves some things to the reader's imagination, as why the chestnut and smaller sizes should be left in the mine if they were regarded as of sufficient value to separate by means of a hand-turned screen, and how the different sizes made by this screen were loaded into different cars.

THE MINE TIPPLE

Bituminous coal is prepared for the market at the tipple, where it is dumped from the mine cars into railroad cars for shipment to the point of consumption. The term tipple is applied indiscriminately to any kind of structure by means of which the coal is dumped into the railroad cars. It may consist of anything from a simple temporary frame structure used for dumping a limited tonnage of prospect coal, to a very elaborate combined headframe and tipple, equipped with several sets of screens, picking tables, conveyors, elevators, etc. In shaft mining, the headframe by which the coal is hoisted from the shaft is usually incorporated in the tipple structure itself, thus developing a distinctive form of structure varying in some respects from the simpler form of tipple used in drift or slope mining.

A rather unusually well-equipped example of a typical steel shaft tipple is shown in Figure 43, which has been taken from *Coal Age*. The higher part of this structure to the right is what would properly be termed the headframe; it is set directly over the shaft from which the cages, with the coal cars on them, are hoisted by means of the steel wire rope as shown, the rope passing over the large sheave wheel at the top and thence down to the hoisting engine, located on the other side of the headframe. The cage rising from the shaft engages a tripping device which automatically dumps the mine car as shown in the figure, the coal falling into a weigh hopper *B*, where it is weighed by means of a system of levers connecting to a quick weighing dial in the beam box *A*. The miner's check is removed from the car and the weight of the coal credited to his number on the weigh sheet, the cage in the meantime returning down the shaft.

When the coal has been weighed it passes into the mechanical feeder *C*, from which it is automatically fed in the quantities desired, either to the conveyor *I*, at the right, or the screen *D* to the left. The conveyor *I* is used for distributing coal to several bins in the rear of the tipple from which it is loaded as required in wagons for the local domestic trade, which happens to be of more than ordinary consequence at this particular mine. As it is necessary that the domestic coal be screened, the bottom of this conveyor is equipped with an adjustable bar screen and the fine coal passing through this enters the elevator *J* by means of the chute *N*.

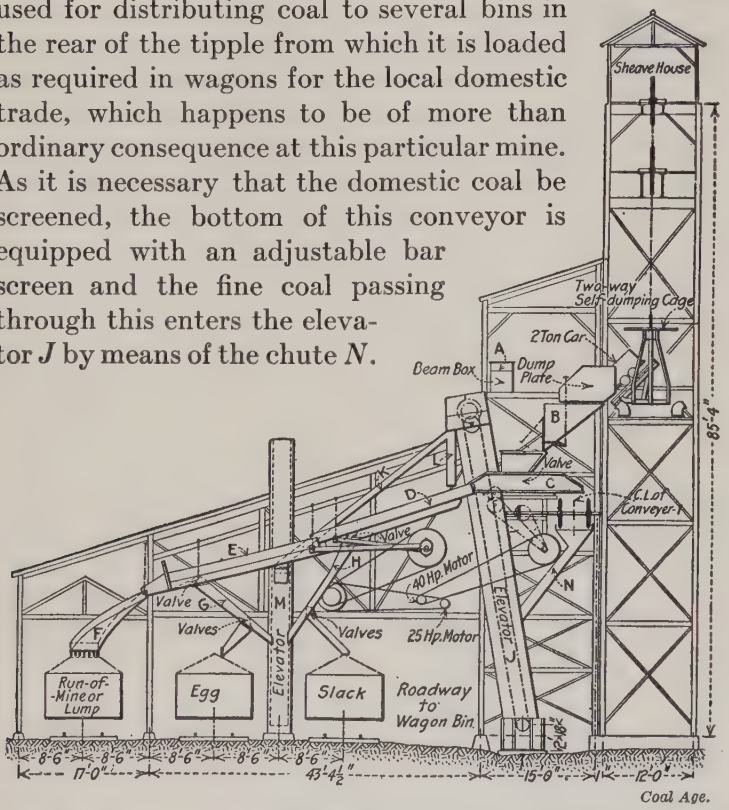


FIG. 43. Typical example of the modern steel shaft tipple used at the bituminous mines to-day.

The coal to be loaded on the railroad cars is passed from the mechanical feeder *C* on to the shaking screens *D* and *E*, which remove the smaller sizes, the lump coal passing off the end into the railroad car by means of the

spiral chute *F*, which can be raised as the car is filled, thus reducing the breakage. These shaking screens are moved back and forth a distance of six inches at the rate of one hundred times per minute by means of the twenty-five-horsepower motor and the driving mechanism shown in the drawing. Where it is not necessary to grade the coal closely, these screens are set at a steeper inclination so that the coal will pass over them by gravity and the shaking mechanism is dispensed with.

The shaking screen *D* has holes $1\frac{1}{4}$ inches in diameter and the coal passing through these holes is classified as slack. It drops on to a plate beneath the screen and is diverted by means of a valve shown in the figure into the chute *H* by means of which it may be passed into the elevator *M* or directly into the railroad car for shipment. Screen *E* has oblong holes $2\frac{1}{2}$ by $3\frac{1}{2}$ inches, the coal passing through these being classed as egg. This egg coal passes through chute *G* into the railroad car or elevator as may be required, in the same manner as the slack coal. When it is desired to make run-of-mine coal the valves in the screens *D* and *E* are closed and the entire output then passes out the spiral chute *F*. Provision is made so that various combinations can be worked out as the market demands may require.

The coal for the wagon trade is screened again as it is loaded and the fines thus obtained are brought by means of another conveyor to the foot of the elevator *J*. The slack coal handled by this elevator may be put on to screen *D* through the chute *L* or passed over to elevator *M* by means of the chute *K*.

These are the salient features of the average tipple designed to handle in the neighborhood of three thousand tons of coal in an eight-hour shift. The capacity of tipples varies from a few hundred tons up to as much as

thirteen thousand tons per day, the latter representing a rather spectacular forward step in tipple design achieved in 1923 by putting the output of two large mines over a single tipple. The enormous first cost of an installation of this kind would necessitate a very large coal reserve to justify the expenditure, since mining plants have but a negligible salvage value and a sustained production on this scale would soon deplete an ordinary field. The capacity of tipples seldom exceeds eight thousand tons per day and two thousand to four thousand tons would represent the range in average practice.

The tipple here described is designed for a shaft mine but could be readily adapted to a slope or drift mine by substituting a trestle leading back to the hillside where the mine is located for the headframe. The mine cars would then be brought out to the tipple in large trips and dumped by means of an automatic end or rotary dump, after which the screening process would be the same as shown in the illustration. In this type of tipple it is the usual custom to weigh the cars before dumping so that the weigh basket shown in this figure could be dispensed with.

THE ANTHRACITE BREAKER

The breaker is to the anthracite industry what the coal tipple is to the bituminous, though there is little comparison between the two. The modern anthracite breaker is a massive steel and concrete structure, the cost of which runs into a million dollars or more, and embodying every known device for sizing, cleaning, and handling coal. The raw coal usually enters the breaker at the top and passes down by gravity through the various stages of its treatment, the cleaned product being assembled in bins according to sizes at the bottom, ready for loading in railroad

cars. The breaker includes an exceedingly intricate array of screens of various kinds and sizes, jigs and picking tables for washing and cleaning the coal, crushers, chutes, conveyors, elevators, together with the machinery for driving all of this different apparatus.

An example of a modern breaker is shown in Figure 44 and a flow sheet, by means of which we can trace the

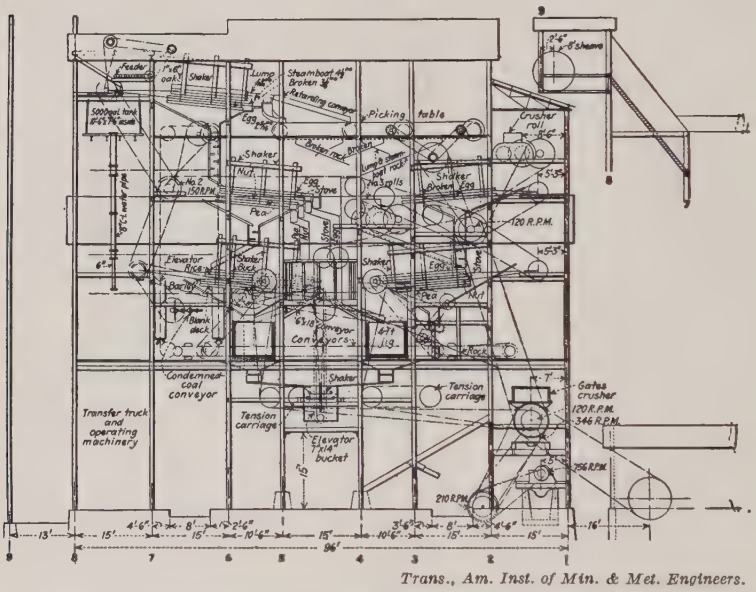
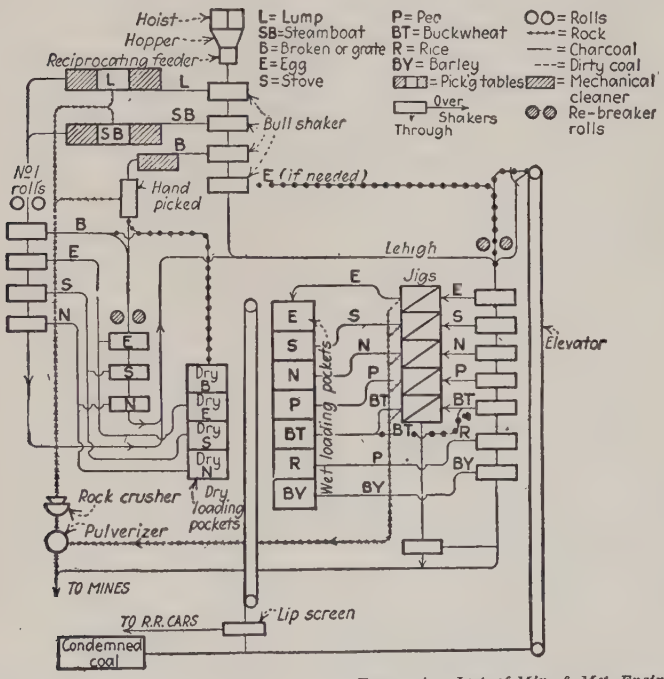


FIG. 44. Cross section of a modern steel breaker showing arrangement of machinery for preparing anthracite coal.

passage of the coal through the various treatments, is given in Figure 45, both of these figures and the accompanying descriptive matter having been excerpted from the paper already mentioned in the *Transactions* of the American Institute of Mining Engineers. In Figure 44, the sheave wheel and head house shown in the upper right-hand corner belong on top of the columns of the same

number in the upper left-hand corner, having been placed in their present position for economy in space.

The coal is hoisted to the top of the breaker by means of a wire rope attached to a hoisting engine and passing over the eight-foot sheave wheel, where it is dumped



Trans., Am. Inst. of Min. & Met. Engineers.

FIG. 45. Flow sheet showing the various processes of treating the coal in the breaker shown in Fig. 44.

into a hopper. From this hopper it is passed by means of a mechanical feeder on to a four-deck shaking screen which separates the coal into lump, steamboat, broken, and egg coal. This feed and shaking screen are clearly shown in the figures, the latter being designated as the bull shaker in Figure 45. The lump and steamboat

sizes are run over separate picking tables, where they are carefully hand picked and then put through a crusher (Number 1 Rolls) in order to reduce them to a commercial size. From this crusher the coal passes on to another four-deck shaking screen which separates it into broken, egg, stove, and nut. The broken coal can now be sent direct to its pocket for loading on the railroad cars or, if there happens to be no demand for this size, it is put through another crusher, after which it is again screened into egg, stove, and nut coal, which unite with the same sizes from the previous screen and pass into their appropriate bins ready for loading into railroad cars.

Returning now to the bull shaker, it will be observed that the broken coal passes through a set of mechanical pickers, after which it is hand picked to remove the slate. It then joins the broken coal from the screens below the Number 1 Rolls and can either be recrushed to one of the more popular commercial sizes, or sent direct to the bins for shipment, as may be desired. The part of the breaker so far considered has used only dry cleaning in contradistinction to that now to be described.

Returning once more to the bull shaker it will be observed that provision is made for separating egg coal on the last screen of this series if needed for further reduction or the final output of the bull shaker may be joined with that from the two sets of screens previously described in the dry section of the breaker. The coal from these sources is then conducted to a set of fine-coal screens, where it is separated into egg, stove, nut, pea, barley, rice, and buckwheat. The last two of these sizes are then passed directly into the bins for shipment and the balance are put through a set of Lehigh Valley jigs for cleaning by the wet process, after which they too pass into their respective loading pockets.

This particular colliery has adopted a method of backfilling the old mine workings by what is known as the silting process in order to facilitate the removal of the pillars. All the refuse material recovered in the breaker is therefore reduced to an impalpable dust by means of a pulverizer and then pumped back into the mine workings where it dries out and hardens eventually, thus successfully replacing the coal which has been extracted. As will be noted in Figure 45, provision is made for conducting all of the refuse matter from the jigs and picking tables to the pulverizer for this purpose.

Inspectors are provided at the breaker to observe the quality of the coal as it is loaded. There may be occasions when the preparation is imperfect for some reason, in which event the car is condemned and returned to the breaker for another treatment. The method of returning this to the breaker is shown in Figure 45.

Anthracite breakers are constructed in a multiplicity of designs, even those of the same company showing a wide divergence at times. There is also a great difference of opinion as to the most efficient types of jigs for cleaning the coal and this applies equally well to all the equipment used throughout the breaker. Unlike the bituminous tipple, the new breakers are seldom constructed at the mines, a single breaker, centrally located, usually handling the coal from several mines. The cost of the modern breaker is so excessive that the depreciation charge, if confined to the output of one mine, would be prohibitive.

WASHING AND CLEANING THE COAL

Viewed in its broader aspects there are two general methods of cleaning coal, hand-picking and washing. The perfection of machinery for use in cleaning coal to a point where it will handle all sizes and almost any kind of im-

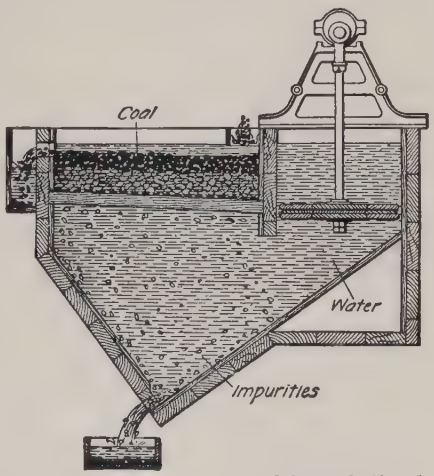
purity, together with the mounting costs of hand labor, have resulted in this latter method gradually disappearing, though it is still finding some application. As an example of the savings effected by the use of mechanical cleaning, one of the anthracite companies installed four automatic jigging machines at its breaker and was immediately able to reduce its labor force from one hundred and five to thirty-five men and boys and at the same time achieved a marked improvement in its preparation.

In the field of washing we are largely in the experimentation stage, with numerous modifications of the existing methods in course of development. Among these is an attempt to introduce the methods of separating metals, employed in the metalliferous mines of the West, the adoption of which might cause the average consumer to feel that coal is indeed worth its weight in gold. But up to the present time the principle of the coal jig has maintained its dominant position as the chief method of separating the impurities from coal. Many applications of this principle have been devised for practical use but all rest on the same basic idea.

It is a well-known phenomenon that materials of different specific gravity, or weight, will settle in water at different rates of speed. Fortunately there is a distinct line of demarcation between the specific gravity of coal and the various impurities that are found with it, so that we are able to take advantage of this to effect a separation of the two. The specific gravity of bituminous coal varies from around 1.10 to 1.35 while that of the impurities common to the coal measures is from 1.60 to 3.0 or more, so that it remains only to devise a method for the practical application of the above principle to separate the impurities.

One method of accomplishing this is shown in Figure 46,

which is a cross section of the plunger type of jig. A repository for the coal to be treated is provided in the upper part of the left two thirds of the jig as shown in the illustration, this being usually from four to eighteen inches deep and provided with a screen in the bottom. The right one third is taken up with a plunger which moves up and down, giving a pulsating motion to the water in the jig. The downward stroke of the plunger forces the water up through the bottom of the screen, creating a current which tends to lift the material above it and as this settles the heavier impurities go to the bottom, leaving the lighter coal on top. Fresh water is fed into the jig above the plunger on the right, through which it passes by means of an automatic valve, and the surplus passes off to the left, taking the washed coal with it as shown.



Mines and Minerals.

FIG. 46. Cross section of a washing jig for cleaning coal.

The illustration shows how the coal and impurities form in two separate beds. There are several methods of removing the impurities, a rather ingenious one being to put in a bed of some material such as feldspar having a specific gravity about halfway between the coal and the impurity treated. This feldspar is large enough so it will not pass through the screen and it tends to form a blanket between the coal and the impurities, the latter

working down through it and dropping through the screen to the bottom of the jig, where they are removed by means of the valve, as shown, or a small conveyor.

Jigs are sometimes designed to classify the coal into an intermediate grade as well as the cleaned coal and refuse, and this third grade may be treated over again, rejected entirely, or when a specially clean product is not required, it may be run in with the cleaned coal. It must be remembered that the cleaning process is not an exact science and that the results contemplate only a more or less large reduction in the percentage of impurities in the coal. The work of the jigs is confined principally to the smaller sizes, though they are now being constructed to handle larger grades. As the larger lump may contain a very considerable percentage of impurity within itself, the results obtained on this grade cannot be expected to compare with those on the smaller sizes.

The general tendency in jig design is towards larger units and more permanent construction. They are quite commonly made of steel and reinforced concrete now instead of the frame construction shown in the illustration, and have a capacity of from fifteen to twenty tons per hour. Separate jigs are required for each size of coal and in an anthracite breaker handling eight thousand tons of coal per day a large number of each size would be required.

Hand picking of coal has descended to us from the earliest days of the mining industry. As its name indicates it contemplates a removal of the foreign material in the coal by manual labor and is practiced from the time coal is loaded on the cars in the mine until it is put on the railroad cars under the tipple. Miners are constantly cautioned against loading any loose rock, which there is a strong temptation to do because of the extra weight, and

are sometimes penalized for doing so. Boys are usually employed for removing the rock and slate at the anthracite mines and to facilitate the work the coal is run on to picking tables, which are, essentially, large, slow-moving conveyors. The coal is spread on these in a thin layer and the boys remove the rock as it passes by them. Consumers are becoming constantly more discriminating as to quality in their coal supplies and operators are now giving this their closest attention, sometimes keeping three or four men on the railroad cars as they are loaded to remove any chance pieces of rock that may appear.

Anthracite coal is separated into seven common sizes, which have been standardized as follows: buckwheat number 3, everything less than $\frac{3}{32}$ inch; buckwheat number 2, $\frac{1}{4}$ to $\frac{5}{16}$ inch; buckwheat number 1, $\frac{1}{4}$ to $\frac{1}{2}$ inch; pea, $\frac{1}{2}$ to $\frac{3}{4}$ inch; chestnut, $\frac{3}{4}$ to $1\frac{3}{8}$ inches; stove, $1\frac{3}{8}$ to 2 inches; egg, 2 to $2\frac{3}{4}$ inches. There are also some sizes larger than these such as grate, broken, and steamboat, but no generally accepted standards have been adopted for these and they are seldom made except on special orders.

The reader will have inferred from the description of the anthracite breaker that the coal is broken up indiscriminately without any regard to the extent of the reduction in the sizes, but this is very far from being the case. As an example, the difference in the market price between buckwheat number 1 and pea coal is about two dollars per ton. A good-sized colliery will produce two hundred and eighty thousand tons of pea coal a year and if even ten per cent. of this should be reduced to buckwheat number 1 by rough handling the loss to the company would be fifty-six thousand dollars a year on this one size alone. It can be readily seen, therefore, that very extraordinary measures to prevent breakage

are justified and the breaker designers have worked out many ingenious methods for accomplishing this end.

There is not such a wide difference in the price of the different sizes of bituminous coal and in addition a considerable portion of this is sold as run-of-mine, that is, just as it comes from the mine without any screening. Only four general sizes are recognized in the soft-coal trade, as follows: slack, everything below $\frac{3}{4}$ inch; nut, $\frac{3}{4}$ to $1\frac{1}{2}$ inches; egg, $1\frac{1}{2}$ to 4 inches; lump, everything over 4 inches. These sizes are by no means standardized as to name and dimensions given, the practice varying in different fields and particularly in the Middle West, where an intensive domestic trade has developed the need of a highly specialized preparation which somewhat resembles that of the anthracite breakers.

Three general methods of separating the coal into the different sizes are in use, — gravity and shaking screens and the revolving screen. The gravity and shaking screens, as already pointed out in the section on The Mine Tipple, are similar in construction, differing principally in their method of operation. The gravity screen is set at an angle of about thirty degrees so that the coal passes over it of its own volition, but necessarily at a rather high speed so that the screening process is rather imperfect. The shaking screen is set at less inclination and even horizontal in the case of some special types, so the coal passes over these more slowly and, being agitated in the meantime it effects a more perfect separation. These screens are made with both perforated plates and with iron bars, set on edge longitudinally at the required intervals, the latter type being preferable for heavy service.

The use of revolving screens is confined largely to the sizing of the smaller grades. These screens are made of

perforated plate or wire mesh and are usually designed to screen several sizes, as will be noted by reference to Figure 42, which shows one of the early applications of this type of screen. The screen is set at a moderate inclination and the coal is fed in at the high end, passing through and out the lower end as the screen is revolved. This type of screen is used largely in the anthracite regions for separating the smaller sizes and produces very efficient results.

PART THREE

DISTRIBUTION OF COAL

CHAPTER I

Coal Varieties and Values

An attempt to prepare an intelligent classification of all the different varieties of bituminous coal, their points of origin, composition, special uses, trade names, etc., would involve a work spreading through several volumes and precipitate the author in an endless series of controversies. As will be shown in this section, the matter of trade names in connection with bituminous coal is seldom of important significance to the purchaser, since, even assuming that the coal originates in the same mine, the quality within the mine itself may vary from day to day. The retail dealer who has built up a trade name for his product at a considerable expenditure for advertising and who has made a sincere effort to furnish a really high-grade fuel under this trade name, even though it may originate from several sources, naturally would be expected to resent the use of this name by a competitor.

On the other hand there are certain broad classifications of coal in trade circles that are of the first importance from a commercial standpoint. It is necessary that the student of the coal industry should have a thorough grasp, not only of the fundamental characteristics of these different varieties, but of the purpose to which they are each best adapted, as well. Since these differences in quality are due largely to the varying conditions under which

the coal beds have been formed, it is necessary, therefore, that we glance briefly into the accepted theories governing the formation of coal.

GEOLOGICAL CONSIDERATIONS

Coal was formed under conditions that are comparable with our present-day peat bogs. Imagine these conditions much accentuated by a humid atmosphere, producing a magnificent tropical growth, far superior to anything existing to-day. This vegetation lived, died, and decayed in vast swamps, sometimes of very considerable depth, and was then covered with overlying deposits of sand and clay, thus beginning their long period of conversion (some tens of millions of years) into the coal we are mining to-day.

The reader must keep in mind the great profusion and wide extent of these early forests of vegetation in order to properly visualize the wide areas over which our coal seams are spread. Erosion of later geological periods has wiped out vast stores of potential fuels so that we have remaining to-day only a tithe of the original reserves. But even so we are sometimes able to trace the same seam of coal for a hundred miles and the same coal-bearing measures for a thousand miles.

During certain periods, as reckoned in geological time, the deposition of these pre-coal peat bogs was a constantly recurring phenomenon with varying intervals between when the sandstones and shales were being deposited. The paleontologists have divided these into three main coal-bearing epochs, the Tertiary, Cretaceous, and Carboniferous, the first of these being the youngest and of the least economic importance, and the last the oldest and most important. These periods are broken up into still further divisions and subdivisions which vary widely

in different parts of the country but which are not of sufficient importance to justify discussion here.

The depth of the peat depositions determined the thickness of the seams as we find them to-day, a matter of very great importance in mining operations. This thickness varies from a mere streak up to as much as four hundred feet, though this last (a coal seam in China) is a unique deposit and has no parallel among the known coal fields of the world. There are two seams in this country eighty feet in thickness and some few around forty to fifty feet, but the great bulk of our mining operations to-day is being conducted in seams between four and ten feet thick.

The overlying deposits of sand or clay destined to form the sandstone or shale roof of our mine, having been started after the cessation of the vegetable growth, may continue indefinitely or terminate in conditions again favorable to the formation of another peat bog. In the former case there will be no further coal seams and we pass beyond the coal horizon, or reach the top of the coal-bearing measures, as it is commonly termed. Where additional peat deposits occur, the interval between these may again vary from a mere streak to several hundred feet. When the deposition of extraneous matter is a few inches or less in thickness, it frequently becomes so intermixed with the pure coal on either side that it contains a varying amount of carbonaceous matter itself, and is commonly called "bone coal." But when the deposition of foreign matter is sufficiently thick to retain its individuality, say four or six inches or more, it then becomes a parting. And when the parting reaches one to three feet or more in thickness, the expense of handling it is too heavy in mining operations, and the coal on either side is treated as distinct seams and mined separately.

The student of the coal industry should familiarize himself with these few simple phenomena in coal geology, as they have a far-reaching effect on coal economics. The bone coal above mentioned is the most prolific cause for the frequent complaints one hears of a consignment of poor or dirty coal. Coal seams are sometimes impregnated with this to such an extent as to be worthless, while others can only be marketed by installing special equipment for washing or picking the coal. The unexpected thickening of partings has increased mining costs at some operations to a prohibitive level, or introduced burdensome complications in the system of mining at others.

Besides the matter of impurities in the coal seam, there are also certain geological phenomena to account for the wide range in the character of the different coals as we find them to-day. The first of these is the development of great mechanical forces, exerting enormous pressures on the coal and accompanied by varying degrees of temperature. The second is the time element, which is of importance chiefly as fixing the duration of the first.

The mechanical forces acting on the coal are divided into two classes: first, the latent pressures naturally resulting from the deposition of hundreds or even thousands of feet of superincumbent strata on top of the coal; under these conditions there would normally be no special change in temperature other than the slight increase as we approach the center of the earth. Second, the great incalculable forces resulting from contortions in the earth's crust, whereby our impressive mountain ranges were brought into existence and the strata in the affected area subjected to great pressures and left at all conceivable angles from the horizontal. These movements are believed to have been accompanied by considerable heat,

and to these we might add the heat occurring in proximity to volcanic eruptions, the effects of which were spread over a considerable area by the intrusion of the lava between the existing strata.

Thus we have the geological explanation of phenomena that have been a dominant influence in the economic consideration of the coal seams. The results of these pressure and heat-generating agencies have been to devolatilize the affected coals and to enrich their carbon content, and it is due to these causes that we have the very wide range in the varieties of coal there are in this country.

ANALYSIS AND CLASSIFICATION OF COALS

The analysis of a coal is the chief factor in determining its economic value. But a comparison of different coals on this basis is a matter to be approached with some caution. Methods of analyzing have never been standardized and different methods must indubitably give different results. The analyses of two separate coals, made in different laboratories, are not, therefore, strictly comparable. The method of taking the sample for analysis will also cause wide variations in the results and even the personal equation of the chemist conducting the test will be the cause of minor differences in the results.

A carefully selected list of coal analyses from all parts of the country is given in Table 13 in the appendix. These analyses are from the Bureau of Mines and the U. S. Geological Survey and are made under the standard methods adopted by these institutions. The method of sampling was also standardized, so that the results may be regarded as readily comparable, for all practical purposes. The analyses are of "mine samples as received," which means that the sample when cut in the mine was

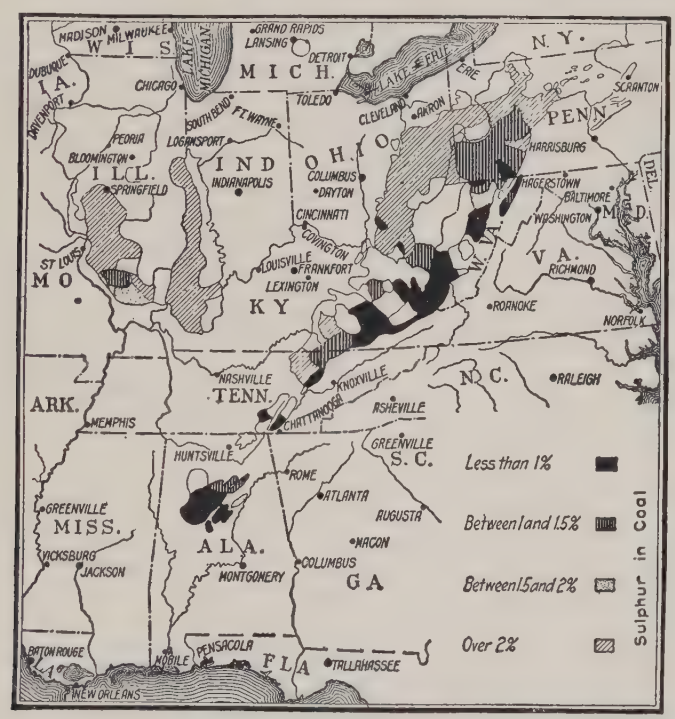
immediately sealed in an air-tight receptacle to eliminate any variations in the moisture content. This refinement in sampling is an important consideration in comparing the economic values of the different coals, as "air dried" samples will show substantially less moisture.

Of the constituent parts of coal, the fixed carbon content is the most important; other conditions being the same, the amount of this ingredient will determine the heat-producing quality of the coal. The volatile matter is the next important constituent in the coal, the ratio of this to the fixed carbon being the factor by which we determine the rank of the coal, as will be shown below. The volatile combustible matter consists of carbon, hydrogen, and oxygen in varying amounts, according to the character of the coal. A large percentage of volatile matter indicates a coal that ignites readily but gives off a dense smoke, except where special furnaces are used.

Moisture, ash, and sulphur all exert a deteriorating influence on the quality of the coal. Moisture is present on the surface of the coal and held by capillary attraction in the pores as well; the former disappears when the coal is exposed to a dry atmosphere, but the latter absorbs a definite part of the energy in the coal when burned. For instance, a moisture content of ten per cent. would indicate two hundred pounds of free water present in a ton of coal, to disperse which involves burning thirty-three pounds of the average coal, making a total loss of two hundred and thirty-three pounds of coal to the ton.

The ash in coal is due to some inferiority in the vegetation from which it was formed, an infiltration of foreign matter into the pre-coal peat bog, or to bone coal. In a coal containing ten per cent. ash this would mean that for every ton used there would have to be two hundred pounds

of extraneous matter hauled from the mine, loaded on railroad cars for transportation to the point of consumption, and there shoveled both in and out of the furnace before some final disposition is made of it. Ash is also a prolific source of trouble in burning the coal, due to the



Coal Age.

FIG. 47. Sketch showing variations in sulphur content of coals in the Eastern Fields.

tendency of some grades to clinker in furnaces of certain types.

Sulphur is found in coal in several forms, varying from a more or less intimate combination with the coal to distinct and separate nodules, containing fifty per cent. or

more of pure sulphur. These last are exceedingly hard and when present in large quantities they are a potential source of trouble in the mining operations. The fumes from a high-sulphur coal when burned are of a very corrosive nature, so that this is classed with the other objectionable impurities.

The occurrence of sulphur in the coal fields of the eastern part of the United States is shown graphically in Figure 47, which we have excerpted from *Coal Age*. It is interesting to observe that the area of least sulphur content lies along the eastern escarpment of the Alleghany Mountains, in much the same territory as our best grades of coal.

The heat value (British thermal units) given in the sixth column of Table 13 is one of the most common methods of expressing the approximate heating value of a coal. A British thermal unit is the amount of heat that will be required to raise the temperature of one pound of water one degree Fahrenheit.

The problem of working out a graduated scale of fuel values that would apply equitably to coals in all parts of the country has been accomplished on rather broad lines and with considerable success by the U. S. Geological Survey. The Survey based its classification on the carbon divided by the volatile matter content ratio, supplemented by certain allowances for variations in physical characteristics and has set forth the following classification:

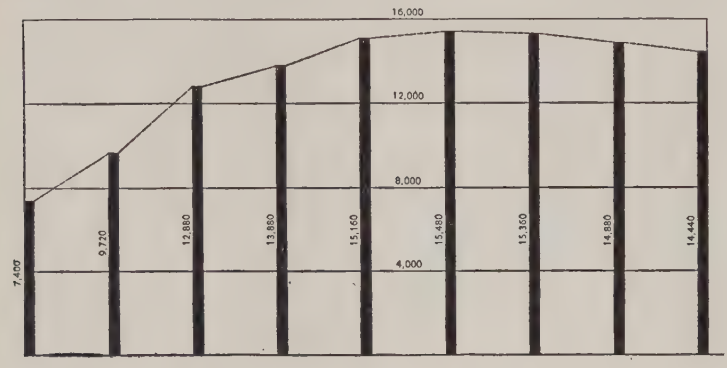
Fuel Ratio From	Fuel Ratio To	Designation	Characteristics
10	60	Anthracite . .	The hard coals, confined principally to eastern Pennsylvania and a few isolated sections of the West. The ideal domestic fuel but not well adapted to steam purposes.

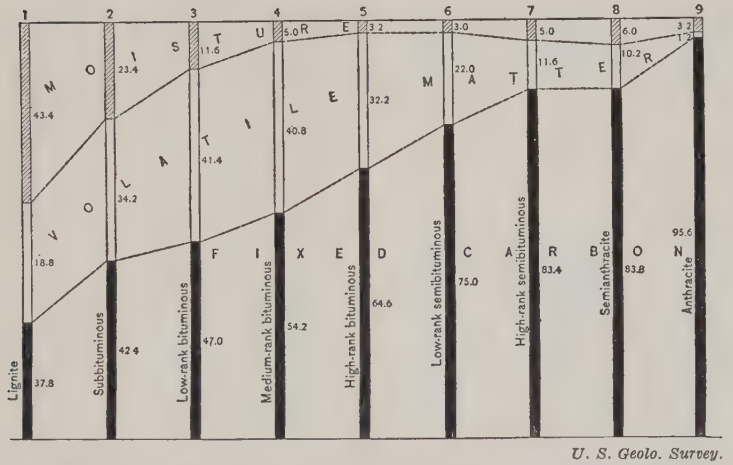
Fuel Ratio From	Fuel Ratio To	Designation	Characteristics
6	10	Semianthracite .	Not so hard and containing less carbon than the true anthracites. Fuel ratio much the same as semi-bituminous, from which it differs in physical characteristics, being somewhat harder. Deposits of this coal are unimportant and it is usually sold as a true anthracite.
3	7	Semibituminous . (Supercoals) . Coking coals .	Commonly known as the smokeless coals. These are the best steaming coals in the country, if not in the world. Used extensively as steamship fuel. Chief objection to this coal is its friable nature, which causes it to break up into small sizes. Found principally in isolated sections of the East but also in some sections of the West. Contains the best coking coals in the country.
0	3	Bituminous . . 1. Coking coals 2. Gas coals 3. Cannel coals 4. Block coals 5. Splint coals	Coals of this and the lower classes have the same fuel ratio and this grade is distinguished by its harder, weather-resisting character. This category contains a wide range of coals, scattered in all parts of the country and very dissimilar in character. The high volatile content makes them valuable gas coals. The cannel coals, containing a large percentage of resinous matter, burn with a long flame and considerable heat. The block and splint coals are almost as hard as anthracite in character and enjoy a certain advantage in the domestic markets for this reason.

Fuel Ratio From	Fuel Ratio To	Designation	Characteristics
0	3	Sub-bituminous .	In this rank have been placed all the coals between the true lignite and the true bituminous. Some of these grades are close to the lower bituminous coals from which it differs principally in its non-weather-resisting capacity. They are distinguished from the true lignites by their uniform black color and absence of the woody texture. Confined largely to the Cretaceous measures of the West, where they are mined extensively, and commonly designated as lignites.
0	3	Lignite	The lignite coals are the nearest approach to the pre-coal peat bog that we recognize as a fuel. These fuels are brown in color and of a notably woody consistency. They slack easily, are liable to spontaneous combustion if stored for any length of time and for these reasons are not of much commercial value, except locally. They are confined to the Cretaceous measures of the West.

In order to visualize the varying nature of the constituents in the different ranks of coal, the Survey has prepared a graphic presentation of these, shown in Figures 48 and 49 which are drawn on an "ash free" basis; that is, the ash has been eliminated from consideration since it is present in approximately the same quantity in all grades, irrespective of their rank. Figure 48 shows the comparative heat value in British thermal units of the different ranks of coal and Figure 49 the carbon-volatile-

moisture contents of the same coals. The figures used in preparing these diagrams are from actual analyses of





U. S. Geolo. Survey.

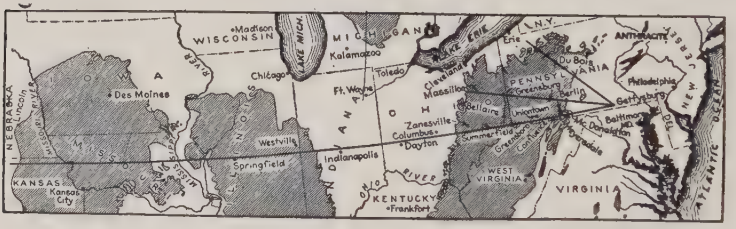
Figs. 48 (above) and 49 (below). The heat value in British thermal units of the different rank coals is shown graphically above (Fig. 48) and the carbon-volatile-moisture contents of the same coals are shown below in Fig. 49.

typical fuels in the different ranks, and they serve to show very clearly the points brought out in the preceding discussion.

An attempt was made, in a paper presented before the

American Chemical Society, to show the decline in quality of coal from east to west. Variations in quality are so diversified as to defy the application of any fundamental rules that will hold true in every case. This east to west deterioration hypothesis is a rule that applies on a broad scale, but must be used with caution when considered locally.

To elucidate this change in quality a line was drawn from Gettysburg, Pennsylvania, following the direction of the Fortieth Parallel, west, as shown in Figure 50.



Am. Chemical Society.

FIG. 50. Sketch showing line on which the volatile graph in Fig. 51 was made.

Characteristic analyses of coals along this line were determined and plotted, in terms of the moisture and volatile content, in the graph shown in Figure 51. Had the fuel ratio formula of the U. S. Geological Survey been used in drawing this graph, instead of the moisture-volatile content, the results, for the purposes of this discussion, would have been more illuminating. However, the figure shows the rapid increase in the moisture-volatile matter content of the coals as we progress to the west.

USES OF DIFFERENT COALS

The development of highly specialized methods of burning coal has brought with it a need for discriminating very closely in the grades required for these special pur-

poses and resulted in a generally exhaustive chemical classification of all coals according to these special purposes. The selection of the most economical fuel for any specific purpose is a matter that must be studied from many different angles. It has, in fact, become the custom in recent years to design power plants to burn certain grades of coal, after due consideration has been given to

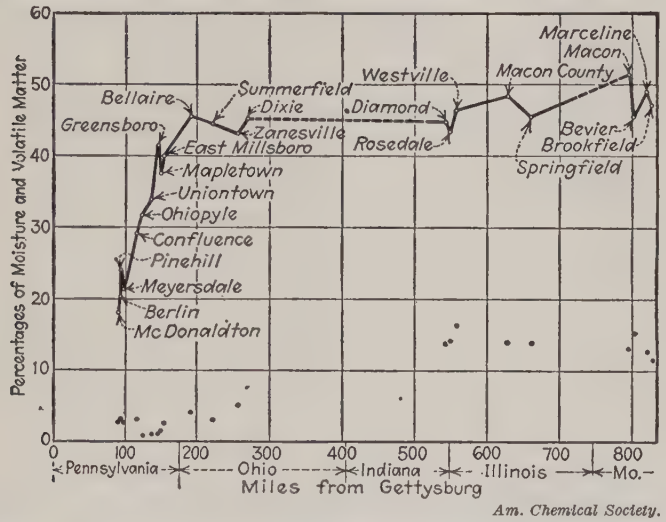


FIG. 51. Variations in the volatile content of coal along the line shown in Fig. 50.

the prospective future supplies. A plant of this kind will not infrequently produce better results with a comparatively low-grade product than it would with a higher quality and consequently higher priced fuel. The distance the coal has to be shipped is another point that must be considered since a heavy freight burden on a coal shipped to a remote point will very quickly wipe out a considerable differential in the cost at the mine; and conversely a long haul for a high-grade coal will make it more economical to burn a local product of inferior quality.

Coals are divided into two general classes, steam and domestic grades, the difference being confined largely to the sizing. For instance, in the anthracite coals, egg, stove, chestnut, and pea are known as the domestic sizes and all those below pea coal fall in the steam-coal class. Bituminous coals for the domestic market are mostly screened into one size, lump coal, though in some sections, as for instance in the Middle West, it has become the practice to make several different sizes. All kinds of bituminous coal are used for domestic purposes but those that burn slowly and steadily and with a minimum draft are the best. The smoky, high-volatile coals are specially objectionable for domestic use, particularly in grates. The sulphur content should also be low and the ash should be fine enough to pass readily through the grates.

Coals high in fixed carbon are the best for steam purposes. Any size is used for this, frequently straight mine-run coal, and it has become the custom to designate off grades and qualities that cannot be adapted to any special purpose as a steam coal on the theory that the heavy draft in a boiler will at any rate consume the coal. No general specifications as to what is the best steam coal can be laid down, as this depends largely on the conditions under which it is to be used. A furnace specially designed to burn a certain kind of low-grade fuel would be very apt to give a greater efficiency with this particular grade than it would with some better, or even the best coals. It is not, therefore, a fair test of two grades of coal to compare the results obtained from them under the same conditions of burning, particularly if they belong to distinctive classes.

A good steaming coal should contain just enough volatile combustible matter to insure rapid burning without giving off too much smoke, and the semianthracites and

semibituminous coals come the nearest to meeting these requirements, giving somewhat better results than the true anthracites, even though the latter have a greater carbon content. The tendency of the coal to clinker at high temperatures should also be considered. Some coals will form a clinker, limited only by the size of the fire-box, in a very few hours, and when this clinker is of a pasty consistency, tending to run through the grate bars, these soon become clogged and may even necessitate closing down the furnace for cleaning. Other coals, such as the New River and Pocahontas varieties, may be burned continuously for a number of days without any indication of clinkering. In addition to these points, steam coals should also have low ash and sulphur content.

Coking coals form another variety of fuels of a rather distinctive class. The scientists have yet to discover just what special characteristics cause certain fuels to coke, as we have frequent examples of two coals of almost identical analysis, one of which may produce an excellent coke and the other not respond to the coking process at all. About the only coals that have no coking characteristics at all are those at the extreme ends of the coal scale, the anthracites at the top and the lignites at the bottom. Nearly all of the recognized coking coals have a volatile content ranging from twenty to thirty-five per cent. though there are many coals within these limits which do not coke. The condition and grading of the coal for the coking process are also factors to be considered. Coal that has been exposed to the weather does not coke well as a rule and fine sizes of some coal will produce an excellent coke where larger sizes make but an indifferent grade. Some coals respond readily to the coking process in retort ovens that give but indifferent results in beehive ovens, and so on. A common physical characteristic

that applies to most of the coking coals of West Virginia and Pennsylvania is a distinctly columnar structure caused by vertical cleavage planes in the coal bed.

Free-burning coal is a much abused term sometimes applied to bituminous coals as distinguished from anthracite because they burn more freely and with little or no draft. It is also applied to non-coking coals and those having a large percentage of volatile matter so that it has but little significance except for local use. Fat, dry, and lean coals are terms used to indicate varying degrees of volatile matter, the cannel coals with a volatile content of around fifty per cent. being an example of the first. The gas coals, which are used largely in the manufacture of artificial gas and have a volatile content of thirty-five to forty per cent., are also in this category. Good gas coals yield around ten thousand cubic feet of gas per ton and should contain less than one per cent. of sulphur. Splint coals are rather difficult to ignite but make a very hot fire and are excellent for domestic use in spite of a rather large ash content as a rule. They are much harder than the average bituminous coal, resembling slate in some respects. All these different varieties of coal are sometimes found in seams by themselves and they also occur in bands of varying thickness in seams of ordinary bituminous grades.

BUYING COAL ON SPECIFICATIONS

Unlike other commodities it is difficult, if not impossible, to judge the quality of a consignment of coal beyond certain obvious facts, such as the size and general character, whether it be lignite, bituminous, anthracite, etc. A car of lumber can be graded accurately as to quality with little or no difficulty and a shipment of pig iron can be tested with equal facility, but it is virtually impos-

sible to attain a like refinement in determining the actual heat value of a consignment of coal. Expert inspectors who are present when the coal is being loaded at the mine are able to pass upon the quality within certain limitations, but the use of these would obviously be limited to large buyers, while the results obtained are indefinite at the best.

To overcome this difficulty a system of buying and selling on a basis of actual heat units in the coal has been devised, with penalties for excessive amounts of impurities. Specifications of this kind vary over a wide range, nearly every coal contract embodying certain limitations as to the quality of coal under consideration. The term specification as generally understood, however, contemplates payments on the basis of the exact heat units in the coal as outlined above. These specifications may provide for premiums and penalties when the coal runs above or below a certain specified number of British thermal units, or payment may be arranged entirely according to the number of units shown in the analysis.

In a specification contract calling for one cent for each 25 British thermal units a coal showing twelve thousand British thermal units would thus be worth $4.80 per ton. Such a contract would also probably carry penalties of around five cents per ton for each one half of one per cent. of ash and volatile matter above a certain standard. The sulphur content would also be penalized on a basis of about ten cents per ton for each one quarter per cent. above the standard. Under this method the buyer would, therefore, apparently obtain the full value of the actual heat constituents in the coal he purchases and be protected against the possibility of undue percentages of impurities.

Theoretically this presents the ideal way in which to buy and sell coal but practically it has failed to work out satisfactorily because of the great difficulty and expense

in sampling the coal. There are some operators that contend that even the most thorough sampling of a consignment of coal will not give a representative analysis of the whole and that the final test in any event is the result obtained under the boiler. The coal costs just the same to mine irrespective of what it may analyze and they refuse to consider a method of selling wherein the buyer can penalize them for any apparent deficiencies as shown by an analysis of an occasional sample. Operators in this class refuse to bid on specification contracts, or if they do submit prices they will add a certain percentage to protect themselves against the possibility of penalties.

It must be admitted that the difficulties of sampling are such as to give the operator very good grounds for taking this position, however carefully it may be done. Coal may absorb a considerable amount of water in shipment and the constant vibration of the car en route tends to segregate the impurities in the bottom so that a sample at either the top or bottom would not be representative of the whole car. Very elaborate precautions have been taken to overcome these difficulties but there is still nothing to prevent the one possible piece of rock in a whole car of coal finding its way into the final sample and giving an entirely erroneous analysis.

The producing interests are almost uniformly opposed to the specification method of selling and there are very few consumers that have taken it up to any great extent, one notable exception being certain branches of the Federal Government. Proponents of the method claim it to be the only scientific method of buying and the only one by which uniformity in quality can be assured. They also state that the savings effected more than counterbalance the cost of the sampling, but they have probably not made any allowance for the high prices submitted on

business of this kind. The method finds its chief application where consumers are discriminating as to quality.

COKE

Coke is manufactured from coal by a distilling process which consists essentially of burning it in a closed retort, thus driving off the volatile gases and leaving the original carbon intact. This process is conducted in two distinct types of ovens, known as the beehive and the retort or by-product ovens.

The beehive oven was the first in which coke was made and was used quite extensively up to and including the first decade of the present century. It is now being gradually superseded by the retort oven but is still of sufficient importance to justify some particulars as to its method of operation. These ovens are constructed in hemispherical shapes about thirteen feet in diameter and seven feet high with a twelve-inch circular opening in the top for charging the oven and a two-by-three-foot door in the side for drawing the coke. When in operation the door at the side is bricked up with the exception of a small opening at the top, the size of which is regulated by the coking process. The ovens are lined throughout with firebrick and they are commonly constructed in a double row as close together as possible with a track between on which the charging lorry operates.

The coke is drawn from the oven on to a loading wharf in front, where it is quenched and loaded in the railroad cars for shipment. The oven is then recharged at once while still hot, so that the new charge ignites of its own volition, assisted by the heat from the adjoining ovens. The coking time in this type of oven varies from forty-eight to seventy-two hours, depending on the character of coke desired and the kind of coal used. No attempt

was made to save the by-products resulting from the distilling process and the theoretical losses from this source reach an enormous total. In the later days of the construction of these ovens, efforts were made to conduct the heat from the ovens to the power plant and use it for steam raising, and some important economies were effected along this line.

The retort ovens differ radically from the beehive both in construction and method of operation. They are usually made from thirty-six to forty feet long, seven to ten feet high, and eighteen to twenty inches wide and are constructed in batteries of fifty or more, resembling a row of books on a shelf. The ovens hold around twelve tons of coal each and the coking time is much shorter than in the beehive oven, being usually around eighteen hours for each charge. The retort oven is usually mechanically operated throughout. The charging is done in much the same manner as with the beehive oven but the method of removing the coke is entirely distinct, the doors at each end of the oven being taken off and the coke pushed out into a lorry in which it is conveyed to the storage bins.

Nearly all retort ovens are equipped with facilities for recovering certain of the by-products evolved in the distilling process, the most important of which, in addition to the coke, are: gas, oil, tar, and ammonium sulphate. The tar is used for the manufacture of various drugs, dyes, paints, etc., and the ammonium sulphate furnishes a considerable amount of nitrogen which is valuable as a fertilizer and for other purposes. Roughly speaking, the value of the coke and the by-products obtained by this treatment is about twice that of the coal, and with some fifty-three million tons of coal a year being consumed in the manufacture of coke the importance of the by-products can be appreciated.

The cost of the by-product oven is several times that of the beehive type; the latter were commonly constructed at the mines and abandoned when the mine was worked out, but the high cost of the by-product ovens makes it necessary to realize a greater usefulness from them and they are constructed at the point of consumption so that they can draw on different coal fields for their fuel supply. In addition to the savings above enumerated, the by-product oven cokes the coal in about one quarter the time required in the beehive oven, so it has four times the capacity of the latter.

One of the most important advantages of the retort oven, however, is its capacity for coking a substantially wider range of coals than can be coked in the old beehive oven. There was a time when the steel manufacturers believed that they were entirely dependent on the Connellsville region for a coke to meet their exacting requirements, and with the gradual exhaustion of these, the coal land values in the region advanced in a most spectacular manner. It has now been found that the retort oven will produce a coke quite the equal of the Connellsville product for metallurgical purposes, from several varieties of coal. It has also developed that very satisfactory grades of coke can be obtained from many of the leaner coals of the Middle West by mixing these with some of the recognized grades of coking coals; the Middle Western coals have heretofore resisted all efforts to coke them and the success of these experiments suggests a good many possibilities along this line. A final advantage of the retort oven that must not be overlooked is the greater yield of coke from the same amount of coal. The beehive oven produces about sixty-three per cent. of weight of the coal charged in coke and the retort oven seventy per cent.

Retort ovens came into active commercial use about

the year of 1900, producing six per cent. of the coke output in that year and this percentage has been steadily increasing, while the output of beehive coke has been on the decline since 1916. In 1919 the production of by-product coke exceeded that of the beehive ovens for the first time and the margin between the two has been constantly widening ever since, the by-product production for 1923 being thirty-eight million tons as compared with eighteen million from the beehive ovens. It is apparent that the wasteful beehive oven is rapidly disappearing and its elimination will be one of the most important strides in the interest of conservation that the coal industry has accomplished.

In Table 14 in the appendix we give the production of by-product and beehive coke for the decade ending with 1923 as prepared by the U. S. Geological Survey. The very sharp increase in the output of both kinds of coke in 1923, the figures for which are estimated, was due partly to a general improvement in the iron and steel industry and also to an increase in the domestic consumption occasioned by the long strike in the anthracite fields. Coke is the nearest approach to a satisfactory substitute for the hard coals there is and will undoubtedly become more of a factor in the domestic trade in the course of time, as the anthracite supplies become shorter. When all of the retort ovens under construction at the beginning of 1924 are completed, the total full rated capacity of these under favorable conditions of operation will be 48,350,000 tons of coke.

The value and quantity of the by-products recovered in 1922, as estimated by the Geological Survey, are given in Table 15. This does not include the gas and other by-products used at the plants themselves, so that the final total would be somewhat more than this.

CHAPTER II

Marketing Methods

The processes by which the six hundred and forty million tons of coal mined in this country a year arrive in the hands of the consumer are many and varied. They involve intricate problems in commerce, tariffs, and transportation, and comprise trade organizations that cover the range from a wagon peddler to the most modern type of sales organization. Interspersed between these is a large variety of brokers, wholesalers, sales agents, and retailers, each of whom performs a certain function and thereby adds his quota to the final cost to the consumer.

The U. S. Coal Commission has made the interesting computation that the daily output of bituminous coal would form a single train three hundred miles in length. Coal is by far the most important item of freight handled by the railroads, while the latter are at the same time the greatest consumers of coal, taking twenty-eight per cent. of the bituminous output. The distribution of the remainder is as follows: industrial consumption, twenty-five per cent.; coke and gas works, fifteen per cent.; domestic use, ten per cent.; steel plants, seven per cent.; street railway and power plants, seven per cent.; exports, four per cent.; used at the mines, two per cent.; bunker fuel, two per cent. The U. S. Geological Survey has compiled a table showing the amount of bituminous coal consumed by different industries, which we give in Table 16 in the

appendix. The U. S. Fuel Administration estimated that there were more than ninety thousand commercial coal consumers in the country who were buying coal in carload lots.

SALES DEPARTMENT

For reasons which will be developed in the course of this discussion, not all operating companies find it good business to maintain sales departments of their own. In fact this has been generally confined to the larger companies having a production of half a million tons or more per annum. The maintenance costs of a department of this kind are expensive, so that the cost per ton for a small operator would be prohibitive and the business insufficient to keep such a department occupied. But a sales department might sometimes be justified with a relatively small tonnage of a very unusual grade of coal requiring a specialized effort to market it to the best advantage.

Coal company executives are uniformly prone to force operations at the mine, in order to reduce the overhead costs to the minimum and for this reason they sometimes exert pressure on a sales department of their own with results adverse to their own best interests. It has become the practice with most companies handling their own sales to draw a very strict line of demarcation between the activities and responsibilities of the operating and sales departments. Company selling departments are also handicapped in their work, as compared with coal brokers, because of the limited grades of coals they have to offer the prospective buyer.

On the other hand a company-operated sales department has some very distinct advantages to the operator over any other method of marketing his coal. There is, first, the very important consideration that the depart-

ment will keep the operating end in close touch with market conditions and enable it to work the mines to the best advantage. The company also has complete control over prices and can rely on the efforts of the sales department being concentrated on its product to the exclusion of any other interests. Where a special grade of coal is being produced, a sales department is also better equipped to capitalize any advertising value there may be in it.

AGENTS AND BROKERS

Where the product of a mine is handled through a sales agent, he acts in an intermediary capacity only, having no financial interest, other than his commission, and assuming no obligations as to credits, collections, etc., though it has become the custom for the agent to take care of these matters for the producer. The producer retains full control of the sales policy and is assured of his interests being in the hands of an expert who is in intimate contact with market conditions and has a wide clientele. He cannot, however, build up business good will, and prestige, since he does not come in contact with the consumers of his product, and he is almost compelled to relinquish control of the price he will accept for his coal, within certain limits.

Coal brokers fall into two general classes, those whose business is confined to purely paper transactions and those who operate coal handling and storage plants. These latter are confined principally to dealers in anthracite coal and are limited as to numbers. The coal broker differs from the sales agent in that he purchases the coal directly from the producer and resells it to the consumer, assuming all risks of collections, credits, losses in transportation, etc. He too is an expert on marketing coal within the range of his activities, where he is in close

touch with transportation methods and rules, consumption requirements, etc. The broker extends credits to both his customers and the producer, not infrequently being an important factor in financing the operations of the latter. During periods of scarcity in the market the brokers are often able to turn their product over at unreasonable profits and have thus become a favorite target for governmental investigations. Brokers sometimes also get into the retail business of distributing coal to the householder.

Opinions vary as to the necessity for the intervention of the broker between the producer and the consumer, but with the majority of those in a position to know, in favor of them. The large buyer generally feels that the reliable broker gives him the best advice possible on market conditions and does everything in his power to take care of his customers under adverse conditions. The broker will undoubtedly work to the best interest of his customer, taking care of complaints, settling controversies as to grading of coal, following up cars, and procuring extra tonnages to meet any unexpected need. On the other hand, there are buyers who contend that brokers are the first to exact exorbitant prices when any shortage develops in the market, that they are not to be relied upon in emergencies, cannot supply coal of uniform quality, and in fact cannot do anything that the operating companies themselves may not accomplish equally well.

The investigations of the U. S. Coal Commission disclosed the fact that twenty-four per cent. of the domestic sizes of anthracite coal is sold directly from the mine to the consumer or retailer, fifty-three per cent. is marketed through sales agents and twenty per cent. through wholesalers. The wholesaler is in this case usually bound by the terms of his agreement with the producer to take also

a certain percentage of steam sizes along with the domestic grades, the former being difficult to move in a dull market because of the close competition with the bituminous coals.

The Commission was openly critical of the wholesale trade, declaring that there was unnecessary duplication of service with too many handlers between the mine and the retailer. The reason for this is ascribed to the high profits made with comparatively small investments. In the past decade these rates have frequently been as high as forty per cent. or more, per annum on the invested capital. The profits have been generally such that the returns have equaled the investment every two to eight years. The essential function which the wholesaler and broker perform in the industry is admitted, the objectionable features being the excessive number engaged in the business and their wildly speculative proclivities in times of a short market. The Commission expressed the opinion that the Government should have immediately available a skeleton organization for regulating the trade when such markets develop, in order to keep the margin of profit within reasonable limits. This organization would not be required to function in normal markets, since the competitive character of the business is ordinarily sufficient to assure an equitable price level.

In a very exhaustive study on "Coal Distribution in America" appearing in *The Black Diamond* in 1923, an effort was made to determine the number of sales agents, brokers, etc., engaged in the coal industry. The study was incomplete, covering only two hundred and sixty companies handling about twenty per cent. of the bituminous production and nine per cent. of the anthracite, and the results are therefore subject to revision. They are of interest, however, as indicating the approximate

degree of activity in the various lines. Of the two hundred and sixty companies investigated, the number in the different lines was as follows: sales departments of operating companies, fifty; sales agents, thirty-seven; coal brokers, one hundred and eighteen, of which four were operating storage or handling plants; combined brokers and sales agents, twenty-one; miscellaneous (mostly various combinations of the preceding), thirty-four.

Further interesting light is thrown on the various channels through which coal reaches the consumer in Table 17, which is compiled from data obtained from the same source as the above. This table gives the estimated percentage of coal handled through the different agencies under consideration, for the chief mining districts. The table discloses the interesting fact that substantially the largest proportion of the coal production is distributed through company-owned sales departments, the sales agents being next in importance (many of these are company-controlled as well) and the coal brokers last. It is evident from this that the operating companies have a keen appreciation of the economic importance of keeping firm control over the marketing of their product.

RETAIL DEALERS

The retailer is the last connecting link by which the coal finally arrives in the bins of the householder and also to many of the smaller manufacturing and industrial consumers without rail connections. The U. S. Fuel Administration estimated that there are thirty-eight thousand coal dealers in the country who are engaged exclusively in handling coal and that there are fifty-five million tons of anthracite and seventy-five million tons of bituminous coal handled through this medium annually.

The retailers seldom contract for the coal and do most of their buying direct from the mines, although they also use the other sources of supply previously mentioned. In the case of anthracite, the supply is so limited that the operators have been able to assume a very independent attitude in the distribution of this and have generally adopted the policy of "allotting" tonnages to dealers who have been their customers for some time.

The retail dealer must, perforce, handle every ton of coal passing through his hands and in this respect he differs very radically from the brokers and sales agents, whose business is confined almost exclusively to paper transactions. In the course of this operation the dealer accumulates substantial reserve supplies, performing a service to the public that has a very important economic influence on the coal trade, and one that would entail many hardships if it were to be dispensed with. It has been estimated that the dealers have an average storage capacity of about four thousand tons each, so that the combined aggregate of their reserve supplies for emergencies is adequate to meet any ordinary situation that may develop. It must be remembered in this connection that coal is a bulk commodity that must ordinarily pass directly into consumption with the minimum amount of handling; a ton of coal worth say ten dollars at point of consumption cannot, for instance, be handled and stored with the same facility as a pair of shoes or a garment of equal value.

The retailers' chief customer is, of course, the householder. The U. S. Fuel Administration compiled some statistics on this phase of the industry and found that seventy-five per cent. of the dealers' business was with this class, although it is to be noted that this includes hotels, schools, stores, churches, theaters, etc.

Dealers suffer losses in their business from depreciation in the coal, when handling it from the railroad car into storage, and out again for delivery to the consumer. He also stands losses in transportation from the mine, due to stealing, and discrepancies in weights, due to drying of coal en route, and has to work out settlements for inferior quality with his customers, etc. The depreciation of the high-priced domestic grades into the less valuable fines, or slack coal, amounts to probably ten per cent. of all the coal handled; the dealer must absorb the loss from this cause, together with the expense of rescreening the coal, and find a market for the resulting slack as well. Losses are sometimes occasioned in competition with the irregular trade, mention of which is made farther on, and from credits extended to bad accounts, etc.

As a rule, the dealer extends credit to his customer, but this rests largely on the class of trade he caters to; a dealer in a wealthy suburban district would naturally be more flexible in the matter of credits than one dealing with the more or less migratory population of the poorer sections. Probably twenty per cent. of the dealers have no credit policy of any kind, and about half as many maintain a mixed policy in this respect.

The retailer follows the producer in the matter of prices and is, therefore, obliged to sustain all the complaints from the public incident to high prices in times of shortages. As a rule these complaints against the dealer are not justified, though they may be when he advances his prices concurrent with a similar increase in the wholesale prices, even if he have a considerable tonnage of the low-priced coal on hand.

Purchases of the retailer are usually made f.o.b. mines, per net or short ton (2,000 pounds), except for anthracite coal which is sold entirely on a long ton (2,240 pounds)

basis at the mines. The retailer sells his product to the consumer on a short-ton basis everywhere, except in Pennsylvania and a very few of the cities contiguous thereto, where the long-ton basis is used.

The retailer may have anywhere from a dozen up to a good many thousand customers, taking from one to a thousand tons per annum, all depending on the size of the business and importance of the trade. The typical dealer in household trade would probably have around five hundred customers on his list taking an average of twenty tons per annum. Nearly all retailers deliver the coal to their customers and the motor truck has come into general use for this purpose. As a rule the dealer operates his own motor equipment, supplementing this with hired equipment in times of active demand, though some dealers contract all of their hauling. The cost of delivering to the consumer is nearly always included in the price quoted, except where there are some special conditions such as an unusually long haul, necessity for carrying the coal in, a very small order, etc.

Considered in all its ramifications, the retail trade has a rather extraordinary variety of dealers, an incomplete list of which would include the combined producer, broker, or sales agent dealer; the combined ice, grain, lumber, and building supplies dealer; the legitimate dealer; the manufacturer-who-buys-for-his-employees dealer; the chain company dealer; the mail order and side-track dealer; coöperative dealer, etc. The legitimate dealer resents very keenly the incursion of all these outsiders into his sphere of activity and with some justice in many instances. It is a fact that many irresponsibles engage in activities along this line, and it is only fair that those who make substantial investments in yards and equipment to handle the business should be supported by the public,

who certainly have to rely on the regular dealer in emergencies, in any event.

But where the dealer complains of the "side line" competitor it does not appear that his stand is well taken; the dealer in this class requires much the same equipment and yard facilities to handle building supplies, ice, or grain, which are the most common side lines, and to provide year-round occupation for this equipment must certainly tend to greater economy than would duplication for a seasonal trade. The broker and most producers, as a rule, endeavor to protect the retailer from these outside dealers by refusing to sell coal to them, an exception to this being the consumer-owned mine, the product of which is used largely within itself, so that it is less concerned with the ethics of the commercial markets.

The Northwestern territory has developed a distinctive type of dealer operating on the chain store principle. There are some twenty or thirty comparatively large companies operating in this manner throughout that territory and they handle perhaps half of the retail trade. They have strong financial resources, concentrated and efficient management, and make it very difficult for the independent dealer to compete with them. One of the largest of these is the Weyerheuser lumber combine, which is reported to be operating between four hundred and five hundred yards of this kind. The Northwestern dock companies, which are in turn subsidiaries of the larger operating companies in the East, have also gone into this trade quite actively.

The U. S. Coal Commission viewed the operations of the retail trade in an eminently more favorable light than it did that of the wholesalers. As already pointed out, the Commission expressed the belief that while the retailer was frequently accused of responsibility for exor-

bitant prices and poor grades of coal, it was more often the case that these were matters entirely beyond his control. Profits in the retail trade have been variable in different sections of the country but generally moderate and in no case comparable with those in the wholesale trade. An analysis of the profits of 273 companies during the last half dozen years shows a range of from twelve to twenty-three per cent. on the total investment. Retail prices have, of course, advanced sharply in consonance with those in the wholesale trade, but handling and distributing costs have also increased and net profits per ton and on investment have shown a tendency to decrease if anything. The retail trade is generally closely competitive and it is not believed that it is desirable or necessary to attempt such regulation as the Commission believes would be advisable in the case of the wholesale trade, except in event of an extreme emergency situation.

SELLING PRACTICES AND CUSTOMS

Economic necessity has developed the institution of exchanges for large-scale trading in most of our more important commodities, such as wheat, corn, cotton, etc. The prospective buyer or seller can go to this exchange and obtain the current market value of the product to a fraction of a cent. The value so obtained reflects the composite views of all buyers and sellers in the country and may, therefore, be regarded as an equitable one, determined by the law of supply and demand existing at the moment. Under these circumstances business can be negotiated with a certain degree of confidence and the minimum of delays, and the prospective trend of the market studied to determine the most opportune time to buy or sell, as the case may be.

Coal exchanges have been an accepted part of the coal

business abroad for a number of years, but for some unexplainable reason they have never been adopted in this country, though an effort is now being made to establish one. As a result of this condition, negotiations for coal are conducted through roundabout channels and usually shrouded in some mystery, except in those cases where municipal or government laws require that the business be made competitive by advertising for bids. Sales agents and brokers regard the lists of their clientele as their chief stock in trade, to be guarded with the utmost secrecy, and the latter, strange as it may appear, often resent any publicity as to their prospective purchases, apparently, in order to avoid the active solicitation that always follows an announcement of this kind.

We find most of the coal purchases and sales, therefore, being conducted within a very limited circle, the consensus of opinion within which certainly cannot reflect the current market value as would be the case in an exchange where the entire tonnage of the country was under consideration. Let us examine for a moment the possibilities of waste effort and economic loss under this system. We will assume that a purchasing agent for a large railroad company has been called upon for five thousand tons of coal for a New England destination, through a loss in coastwise shipping. A hurried conference with the mines they have under contract discloses the fact that they cannot make up the deficiency in the grades required and within the time limits specified. He then gets in touch with all brokers and sales agents within his particular circle of acquaintance and asks for quotations. They sense an emergency situation and report back that the coal can be obtained at some premium above the existing market. In the meantime a Pennsylvania operator has encountered some unexpected delay due to shortage

of vessels in the Lake trade, and finds himself with three thousand tons loaded on cars for which he has no disposition; a West Virginia operator has likewise two thousand tons standing on demurrage at New York, through the failure of a manufacturing enterprise to whom it was consigned. These two operators start wiring their selling connections to dump this coal on the market at any price, and thus we have two opposing elements feeling blindly around in the dark, each unaware of the other's predicament, and both doomed to sustain a loss which they would not have to take were there an established medium for the expression of their respective needs.

Such a condition would not be likely to occur where the operators and purchasing agent were in touch with the best class of coal brokers, since it is the special business of these to keep themselves fully informed as to matters of this kind, in the interest of their clients. This serves to emphasize, however, the very important rôle the broker holds in placing the coal in the hands of the consumer under our present methods of conducting the coal business. Market information is one of his principal stocks in trade, and both the producer and consumer must pay him for the composite information he possesses of their respective needs. He draws on all the available sources of information — government reports and statistics, the trade journals, the gossip of his contemporaries, etc. — and must, in addition, have an expert knowledge of all the sources of supply for the market in which he operates, together with the methods of preparation, grades, qualities, and market prices both present and future, in so far as it is possible to forecast them.

The personal equation is also a large factor in the negotiation of coal sales. The supplies for large consumers may be purchased by any of several officials from the

plant superintendent to the president, though as a rule it is made a part of the duties of the purchasing agent. There is frequently considerable irresponsibility in letting these contracts, and too much of a tendency to place the business through some family connections. Seldom, if ever, are the negotiations for a purchase of coal conducted with anything approaching the consideration and effort the seller puts forth in marketing his product. On the other hand the position of the purchasing agent is not an easy one. He must exercise care to provide a product that will meet with the special requirements of his plant, negotiate his contracts at propitious times, and finally see that they are placed in the hands of reputable concerns who can be relied upon to meet their obligations in the face of adverse conditions.

The broker and sales agent conducts his business on a purely commission basis and at figures varying over a wide range. The percentages vary from one to twenty per cent. on contracts and twenty-five per cent. on spot coal with an average of around eight per cent. On a cost per ton basis, the fees vary from two to sixty cents per ton, with an average of perhaps twenty cents. The U. S. Fuel Administration fixed upon a margin of fifteen cents per ton for bituminous and twenty cents for anthracite in the East with a maximum of thirty cents in the West. The American Wholesale Coal Association has suggested an average charge of eight per cent. to its members. In normal markets, the broker must conduct his business along frugal lines to make ends meet, but when the trade is active he has opportunities to increase his profits materially through speculation, though he must do this with caution or sacrifice the good will of his clients.

The United States Coal Commission made an interesting study of the margins accruing to the wholesale dealers

in the anthracite trade, through which medium about twenty per cent. of the production passes. The average for five of the larger cities in November, 1921 and 1922, was found to be twenty-three cents and twenty-seven cents, respectively, with a maximum range of from six cents to $1.40. It must be remembered, however, that the wholesaler engaged in this business is usually required to dispose of a certain amount of the steam sizes in connection with his allotment of the domestic sizes, and that he not infrequently sustains a loss on these. In times of a shortage in the market, even the above maximum is sometimes exceeded, one Boston jobber in December, 1922, having obtained $4.25 above the mine price on a carload of domestic anthracite. Multiple sales between the jobbers themselves is another contributing factor in increasing the cost to the consumer, since he must in the final analysis pay the profit upon each of these sales.

An examination of the reports of some ninety wholesalers for the year of 1913 disclosed the fact that they had made an average profit of 3.6 cents per ton on all the coal handled. In 1917 the average profit for 182 concerns was 10.9 cents, and in 1920, the banner year in the wholesale trade, the average for 333 wholesalers was 15 cents per ton. The year of 1922 showed a very large decline in profits, the average for 424 concerns being only 7.3 cents per ton.

The broker purchases from as many sources as possible in order to provide both a wide variety of coals to meet all the various demands of the market, and to have a large tonnage as well. There are some brokers who may have as many as two hundred sources of supply, but the average is probably between ten and twenty. Some care is exercised in the selection of these, in order to obtain as well-balanced a variety as possible. As a rule the

broker endeavors to balance the tonnage in his contracts with both the producers and consumers, but they frequently arrange to have some free coal to place in the prompt market and so usually their contracts with the producers are for somewhat larger tonnages than they have covered with the consumers. The price quoted to the consumer is usually f.o.b. mine and includes the broker's commission, though some quote f.o.b. destinations and omit their commission.

There has been a marked trend towards a community of interest in a financial way between the producer and the broker in recent years, the latter frequently assisting the former in this way. This assistance takes the form of advances to meet the payrolls at the mine, against future shipments and even sometimes to acquire, develop, or lease additional properties. Occasionally the obligation is extended from the other direction, the operator carrying the broker, pending the receipt of collections on coal he has shipped.

It is the general rule throughout the wholesale trade to extend thirty days' credit on all sales or to have bills payable on the month following receipt of the coal. Very few brokers sell on a strictly cash basis, and it is also a noteworthy fact that discounts for cash are never or very seldom allowed as in other lines. The reason for this last is probably due to the fact that the brokers are working on such a narrow margin of profit, in most instances, that the discount would wipe this out entirely.

The term free or spot coal (also sometimes called prompt coal) has a broader significance than is generally recognized, and is worthy of some analysis. It usually refers to an unsold consignment of coal arriving on the market either through some mistake or misunderstanding or with deliberate intention. In the latter case it may have

been shipped during a very active market, when there will be no question of its being placed, the broker utilizing the time it is en route to negotiate the most advantageous sale possible. Coal sent to a broker for distribution to his various customers also falls in this same category, as does that part of a regular mine output not covered by contracts. Failure to make an expected sale, cancellation of an order, inferiority in grade, and an unexpected reduction in requirements on contracts are all factors that may cause the appearance of spot coal on the market. As a general rule it might be said that any coal not sold or moving on contract is free coal.

The reconsigning of coal has been the cause of a great deal of trouble in trade circles, not from anything inherently wrong in it, but because of the abuses that have been made of the practice. Irresponsible brokers have used it to have coal sent to them without a definite sale, and it has been frequently used to divert coal moving on regular contracts into other channels. Some brokers have even used it as a means of storage for coal, pending the discovery of a buyer. The practice has been reduced by additional charges on the part of the railroads, and some brokers think that it should be dispensed with entirely, though there are others using it with moderation and to the advantage of all concerned. It certainly tends to facilitate distributing coal, and should not be discontinued if some method of exercising control over it can be devised.

The export and bunkering trade in this country has developed some very specialized selling practices and customs. All shippers to tidewater destinations participate in this to a greater or less extent, but it is largely in the hands of some of the more important companies that make special efforts to obtain it. These companies also

have an advantage over others in this business because they usually have handling equipment and facilities at tidewater, where this is necessary, and also agencies in foreign countries who are in thorough touch with market conditions there and able to furnish reliable information as to credits, etc. The Consolidation Coal Company and the Berwind-White Coal Mining Company are examples of the more important operators who are heavily interested in the export and bunkering trade.

Bunker sales are made on both f.o.b. and f.a.s. (free alongside) bases. Customs as to charging for lighterage, trimming, etc., vary, and quotations are made covering all, part, or none of this service as conditions may dictate. The larger companies, having their own lighters, usually include this in their price; the lighters are frequently serviceable for storage purposes when a vessel has been unexpectedly detained and the shipper finds a congestion at the piers. Sales may be made to the captain of the vessel or to officials of the company operating it.

Most of the export business passes over the Hampton Roads piers, with coal originating in the Pocahontas and New River fields, though a very considerable tonnage is also shipped through Baltimore and Philadelphia. Some of the vessels in this trade take a very large tonnage, and considerable preparation is necessary when a vessel is due for loading in order to avoid delays that will involve demurrage charges. Coal is "started rolling down to tidewater" (as it is commonly termed in the trade) in ample time to be ready for the vessel when it arrives, and the cautious shipper will also have some extra tonnage in sight to take care of any miscalculation in the estimates of the amount required; incidentally he will also be prepared to place any surplus that may be left over when the vessel is loaded.

DISTRIBUTION ON CONTRACTS

All coal is sold either on contracts or in the "spot" market, much the same as in other lines of industry. Contracts are made by the producer with the broker, sales agent, and the consumer; brokers and sales agents also make contracts with the consumer. The advantages of contracting are participated in by both parties to the agreement. The consumer is assured of a definite price for his fuel supply and is able to compute his manufacturing costs sufficiently close to justify entering into contracts for the output of his factory, thus completing the circle and stabilizing the business of all concerned. The producer is equally benefited in being able to lay out definite working schedules at the mines, and in being relieved of the expense and trouble of finding a market for his product.

As a rule, producers endeavor to cover not less than half their potential output with contracts, but some contract for the entire mine output and others for as little as five per cent. The Interstate Commerce Commission, in the course of an investigation into the reason for the increased cost of railroad fuel, prepared a statement of the spot and contract purchases by the Class I roads in 1919 and 1920, which we give in Table 18 in the appendix. According to these figures the railroads bought eighty-seven per cent. of their coal on contract in 1919 and eighty-one per cent. in 1920. This is interesting in view of the fact that the railroads are the largest individual consumers of bituminous coal in the country, but it must not be accepted as any criterion for the country as a whole. F. S. Peabody (of the Peabody Coal Company, Chicago) testified before a Senatorial investigating committee that his company usually contracted for about one third of their output.

Coal contracts differ from other contractual agreements through a certain flexibility made necessary by conditions arising which are beyond the control of the operator, such as strikes, inadequate car supply, etc. There have been cases of the most flagrant abuses of these privileges, which have become notorious, and engendered an unwholesome atmosphere of suspicion in trade circles. For instance, let us assume a hypothetical condition of an exceedingly tight market, with spot prices ranging up to several dollars per ton above the average on contracts. Markets of this description are created by a shortage in the car supply, so that it is a comparatively simple matter for the unscrupulous broker or operator to abrogate his contracts on the plea of inadequate transportation facilities and divert the tonnage into the spot market at the advanced prices prevailing there. The consumer is forced into the spot market to make up the deficiencies in his requirements at the high price level, and there are instances on record where the consumers have even rebought the coal in this way that they would in the normal course of events have received on their regular contracts!

It must not be inferred that this is the ruling spirit of the trade; on the contrary, it is the exception, if for no other reason than that the discovery of such practices is more detrimental to those perpetrating them than the gain is worth. There are also conditions in the market where the consumers are in a position to exhibit an equal lack of good faith. Coal contracts usually provide for maximum and minimum shipments, and some even for requirements, and in times of a depressed market, with prices below average contract figures, the consumer is sometimes in a position to pick up low-priced distress coal (shipments threatened with demurrage charges)

at considerably under his contract price. Where contracts permit, some consumers are not averse to taking advantage of such conditions, much to the distress of the operator, who is already hard pressed to keep his mines operating and working organizations intact.

These are the reasons why more of the coal business is not conducted on contracts. This has become more accentuated in the past several years, because this has been a period of violent fluctuations in market conditions, creating strong temptations for practices such as outlined above. Uncertainties of other kinds, such as wage scales, etc., have resulted in unstable conditions and made it difficult for the buyer and seller to fix upon prices. Consumers have shown a decided tendency to buy in the spot market, and we have to go back to 1917 for a strictly normal year in the contract business.

Contracts of the brokers and sales agents with their customers are almost invariably made for the twelve months. Producer to consumer contracts, however, are negotiated for varying periods, though most of these are usually for the year also. F. S. Peabody, who has already been quoted, stated that he had made a contract with the Commonwealth Edison Company to furnish them with five hundred thousand tons per annum over a period of twenty years.

A study of the records of the U. S. Fuel Administration, made in the article on "Coal Distribution in America" already mentioned, disclosed the fact that there were thirty-two long-term contracts for the entire output of certain mines; one hundred and fourteen contracts to be filled according to requirements, and something over three hundred calling for indefinite tonnages on a monthly basis. Most of these contracts were for three years or less, quite a number for five years, some for nine years,

and a few for twenty years. Contracts for the entire mine output are, as a rule, of the longest duration.

Variations in the length of contracts are sometimes made necessary by special conditions as, for instance, in the Lake trade, where the agreements are ordinarily for the season of navigation. Some consumers with large storage facilities contract for their requirements to be delivered at the low point of the season, about midsummer, and coke contracts are usually made for periods of six months. Most annual contracts are negotiated on April 1, to conform with the fixing of the new wage scale in the mining regions, though an exception to this is bunker contracts, which are made for the calendar year.

Contracts as a rule are not made in the retail trade, the term coal contract applying almost exclusively to an agreement between producers, brokers, or consumers. An exception to this rule, however, is contracts of retailers with consumers using considerable tonnages and having no rail connections, such as large apartment buildings, hotels, etc.

In drawing up a contract of the regular form we frequently find that, although the price is fixed, it is subject to change in the event of any change in the cost of mining. These contracts also usually provide that in event of any emergency, such as a car shortage, strikes, etc., the producer will pro rate what shipments he is able to make, according to the tonnages he has under contract.

A great deal of coal moves along certain channels without any contract in much the same way as contract coal. An example of this is the domestic sizes of anthracite which are seldom or never contracted, though regular dealers are nearly always assured of their supply. Understandings of this nature are often the cause of serious

trouble, however, when either party sees fit to discontinue the connection.

PROBLEMS IN DISTRIBUTION

Secretary of Commerce Hoover, of international fame as an economic expert, once declared the coal industry to be the "worst functioning" of any industry in the country. When such an eminent authority views the conditions within the industry in this disparaging light, it is clear that there must be something remiss, and it is of interest to go into particulars.

One of the chief difficulties the industry has to contend with is in the question of transportation, a matter that lies entirely outside of its sphere of influence. The productive capacity of the mines is substantially ahead of any peak load in consumption, whereas the railroads have again and again demonstrated their inability to meet the transportation requirements occasioned by this load. But the responsibility for this condition must not be charged entirely against the carriers. This maximum load usually begins to make its appearance in the late fall, just at a time when their resources are already being strained to meet the heavy movement of farm products; and the increasing movement of coal, together with the decreased efficiency of their motive power as the winter advances, must inevitably throw them farther behind.

It would obviously be unreasonable to require the railroads to equip themselves to meet this abnormal load when such extra equipment would lie idle for perhaps two thirds of the year. But there are other directions in which this problem might be approached. A particularly efficacious remedy would be a judicial elimination of the preferential freight rates on long hauls. Preference should of course be given to very special fuels, such

as anthracite, but there are numerous instances where coal passes through one or more fields containing fuel of the same quality, on its way to the market. Here is a direct and obvious waste of efficiency in transportation for which the coal industry itself is more or less responsible, and the elimination of which would do much to improve the service. The almost incredible inconsistencies of this nature were pointed out by the U. S. Coal Commission, taking the State of Indiana for an example. The Commission found that coal was shipped from the Indiana fields into seventeen different States, while the consumers of Indiana were at the same time receiving coal from seven States.

It is gratifying to note that recent decisions of the Interstate Commerce Commission indicate that they are keenly alive to the evils of the preferential rate on long hauls and that there is a marked tendency on their part to eliminate this. In an opinion on the long-fought problem of a proper differential between the Ohio and West Virginia coals to northern points, rendered in July, 1923, one of the Commissioners expressed the following general conclusions on the subject as a whole:

"There is an opportunity, through the medium of the rate structure, to reduce the average haul, increase efficiency in the use of carrier equipment, reduce carrier costs, bring about available surplus of transportation facilities without increase of carrier investment, concentrate mining labor so as to permit continuous operation, provide steady employment of labor on a basis better for labor, producer and consumer, accomplish an available market surplus of coal and reduce mining and coal prices. It is quite possible that by this means there could be a direct saving of from five hundred million to seven hundred and fifty million dollars a year in the price of coal to the consumer,

with much additional indirect saving through lower rates and reduced manufacturing costs. The increase in the spread between rates from the Ohio and West Virginia mines to the more remote markets will encourage resort to short hauls, create a more efficient use of transportation facilities and tend to eliminate the cross-haul. Long hauls make for congestion, high costs and inefficient service, and a correct adjustment should enable communities to be less interdependent and more nearly self-sustaining."

Careless meddling with freight tariffs is a matter to be approached with some caution, if we wish to avoid violent upheavals in established channels of trade, resulting in heavy losses of invested capital. But if a correction in the freight differentials will effect a saving of around $1.50 a ton on all the coal purchased in this country as indicated by this opinion, together with a substantial improvement in transportation service, the coal industry should be called upon to subordinate its interests to the common good. This may entail temporary hardships on some districts while they are working up new markets, but it would at the same time work to the advantage of others, so that the final result should approximate an average of existing conditions.

Another inefficient and burdensome problem with the railroads is the excessive amount of switching service required because of the large number of very small mines. The average number of cars loaded per day at all coal mines in the country amounts to only four, and it is apparent that with but little more effort from twenty to forty cars could be placed on the mine switch.

The most difficult problem the coal industry has to contend with lies in meeting the demand of the peak load in winter and absorbing the losses occasioned by the summer dullness. The former could probably be handled

if the railroads were able to furnish adequate cars for loading, but as it is now the mines sustain lost time from this cause in the winter, and in the summer they are shut down for lack of orders. The U. S. Coal Commission is authority for the statement that a working schedule of three days a week causes an increase of twenty-five per cent in the cost of the coal as compared with full-time operations.

There are several possible remedies to this difficulty, the first and most obvious of which is storage of coal in summer, which will be discussed later on. The anthracite operators have effected a satisfactory solution to this problem by making a flat cut in their circular prices on the first of April of each year, reducing this discount by ten cents a month until the full circular again goes into effect in the fall. The thrifty purchaser is quick to take advantage of this, and a good many thousands of tons of anthracite coal thus find their way into the consumers' bins during the dull summer period, to the mutual advantage of all concerned. The anthracite mines are kept working on fairly good schedules through the summer months by this means, the retail dealer has additional work for his equipment and at a time when weather conditions are more favorable, and the householder gets a better price on his coal and is at the same time protected against a possible scarcity in the winter.

The lack of organization in the bituminous coal industry, together with the great variety of coals and wide range of prices, would make it impossible to put a method of this kind in operation there, but a somewhat similar plan has been suggested that has much to recommend it. This plan contemplates a sliding scale of seasonal freight rates on coal whereby the cost of deliveries in the summer would be sufficiently below those in the winter to stimu-

late a real interest on the part of the consumer in accumulating reserve supplies during the dull period. If satisfactory freight tariffs could be worked out it would appear that this might prove a solution to this problem. The U. S. Coal Commission has also suggested another though somewhat more intricate method. In this method it is proposed that when there is the usual car shortage in the winter, allotments be made to the different mines in proportion to their demonstrated capacity for shipping during the dull summer period.

As will be observed, all of these methods contemplate, in one way or another, the use of storage at the point of consumption. It is clear that storage at the mines cannot be a factor in alleviating these ills, since it is not a question of production but of getting the output to the consumer, so that in the last analysis the problem belongs more to the consuming end of the industry. The storage of a bulk commodity such as coal involves some special problems, of which the matter of cost is of first importance. The U. S. Coal Commission has estimated that the cost of storage, including stocking, reclaiming, and interest on the coal, varies from fifty cents to a dollar and a half per ton. While no data is given from which the interest might be computed, there are certainly plants in operation that are handling coal at very much under the minimum given, though where no such equipment has been installed the cost might well run above the maximum. If the consumers were offered some special financial inducements to stock up in the summer, as by a freight differential, they would in the large majority of cases be quite willing to install the necessary equipment.

According to a paper presented before the American Society of Mechanical Engineers by members of the U. S. Geological Survey who have devoted a great deal of study

to the storage problem, the deficiency in the winter's supply of bituminous coal can be taken care of if the consumers will store twenty million more than their normal stocks. The authors take the position that the consumer has the power to make or break the market by accumulating large reserves. The estimated storage reserves of the commercial consumers vary from twenty to sixty million tons, and with the latter amount on hand the consumer is guaranteed against the possibility of any runaway market. Storage is regarded as a greater factor in stabilizing the market than the mine production.

The great bulk of the storage is done by the general industrial consumers, their stocks ranging from thirty-three to forty-four per cent. of the total storage reserves. The railroads are the next most important consumers in this field, their reserves amounting to from twenty to twenty-eight per cent. of the total. The storage reserves of the retail dealers amount to around fourteen per cent. of the total and that of the electric utilities from eight to eleven per cent. Others of less importance are the by-product and gas companies and the steel works.

The authors also found from figures of the U. S. Fuel Administration that the smaller industrial consumer almost invariably carries the larger stock, comparatively speaking, on the basis of the daily consumption. Thus the consumer using thirty tons or less a week averaged a supply sufficient for one hundred and thirty-eight days, while the one using more than four hundred tons a week usually had a fifty-days' supply on hand.

CHAPTER III

The Coal Markets

As will be gathered from the preceding section the limits of the various coal markets are very clearly defined by certain economic laws. It is obvious, for instance, that the low-grade lignite coals of the Dakotas could not be shipped into the Middle Western field and compete with the fairly good grades from Illinois and Indiana. On the other hand the high-grade West Virginia and Kentucky fuels can, and do, enter into active competition with the Illinois product, in spite of the unfavorable freight differential against them. It will be seen, therefore, that the market for any particular grade of coal will be limited by what might be termed its quality to freight-cost ratio. Thus a North Dakota farmer will find that he realizes more heat units per dollar of cost by hauling his coal from one of the adjacent lignite beds than he would by paying the freight burden on a higher grade product from Illinois or West Virginia; and conversely any extension of the market of the lignite mine will involve an additional burden on the cost that will soon make it the more expensive fuel.

A very small difference in the thermal efficiency of a coal or in the freight cost will soon run into considerable money in the case of a large consumer, so that the more important buyers have been forced into an exhaustive

study of the different coals. This has resulted in drawing very fine lines of distinction between the different grades that would not appear to be justified by the layman. Thus we find the coal markets for the different grades rather closely restricted to certain definite territory, and with a more or less limited number of fuels competing within these separate districts.

Exceptions to this rule occur in the case of some very special fuels and also under abnormal market conditions. The Pennsylvania anthracites, for instance, are able to compete with other domestic coals in all parts of the country because of their distinctive characteristics, which have put them in a class by themselves in this particular field. The Connellsville coke was at one time shipped all over the world because of its peculiarly excellent qualities for metallurgical purposes. Gas, splint, block, and other special coals sometimes move to points outside of what would ordinarily be their market limit.

In times of abnormal markets, such as during the war or when there is a strike in some districts, the established channels of trade may be quickly upset. Buyers facing a possible shutdown of their plants scour the market for coal in all directions, quite often sending their representatives into the mining fields to negotiate purchases. The questions of quality and price are disregarded by those who are hard pressed, and with these barriers removed, coal is free to move in any direction and any distance. Under such conditions we see the Alabama coals shipped into the Northern Ohio market and the relatively lean Middle Western fuels passing through the high-grade districts of Pennsylvania on their way to tidewater. These are very indefinite exceptions, however, when no one can say what may happen, and we are more concerned with tracing out the established channels of trade.

THE ANTHRACITE MARKET

As already mentioned, the Pennsylvania anthracite coals have a wider distribution than any other grade of coal in the country, though as would be expected the bulk of it is consumed in the East near the point of origin. A considerable volume finds its way into the Northwest by means of the cheap water transportation up the Great Lakes and has a wide distribution throughout that territory. Excessive freight costs limit its use in the Middle West to a certain extent, and this increases as we proceed farther West, until the price reaches a point that places it in the luxury class. Nevertheless the fact remains that some tonnages of the anthracite domestic grades are shipped clear through to the Pacific Coast.

Anthracite coals are produced in both steam and domestic sizes, the latter including pea coal and all the larger grades, those below pea coal being used for industrial purposes. The marketing of these two classes of coal are entirely distinct problems, the domestic grades moving practically of their own volition, while the steam sizes enter into competition with the different bituminous coals and require aggressive selling methods to dispose of them. The demand for the domestic sizes has outgrown the supply of these, and since public sentiment would not permit the operators to advance prices sufficiently to restrict the consumption to the productive capacity of the mines, they have adopted the policy of allotting tonnages to their regular customers.

The large cities and dense population of the East absorb most of the anthracite domestic sizes. New York alone, with her stringent anti-smoke ordinances, consumes seven to eight million tons a year, while Baltimore, Philadelphia, and Boston are all large consumers and Toronto

takes nearly a million tons a year. The smaller cities and rural communities also burn a large amount of the domestic grades of anthracite, particularly throughout New England, where it is the principal type of domestic coal used.

About four million tons of the domestic sizes are loaded a year at Buffalo for shipment to various points up the Lakes. Some two million tons of this goes direct to the head of the Lakes at Duluth and Superior, and is distributed from there by rail throughout the Northwest. Shipments to Milwaukee amount to about a million tons a year and the remainder is moved to the different Lake ports. As the season of navigation is confined to the summer months, navigation closing around December 1, efforts are made to get the required quotas forward before much attention is given to the rail trade. This also is quite advantageous to the operators, since it provides an outlet for their product during the midsummer dullness that is characteristic of the domestic trade.

The policy of the leading anthracite companies, controlling some ninety per cent of the production, of fixing standard prices for their product, has tended towards a greater stability in this branch of the industry than is the case with bituminous coal. The regular companies adhere rigidly to their circular price, irrespective of market conditions, and since the demand has exceeded the supply in recent years, they have had little difficulty in realizing these prices. The remaining ten per cent of the production is sold at whatever price the market will bring, sometimes below the company circular during the midsummer dullness and at others above, — most frequently the latter.

The company circular on anthracite stove coal has more than doubled in price during the past decade, as

will be seen by reference to Figure 52, from *Coal Age*. During 1913, 1914, and 1915 this grade of coal sold at $3.75 per gross ton at the mines, with a discount of fifty cents

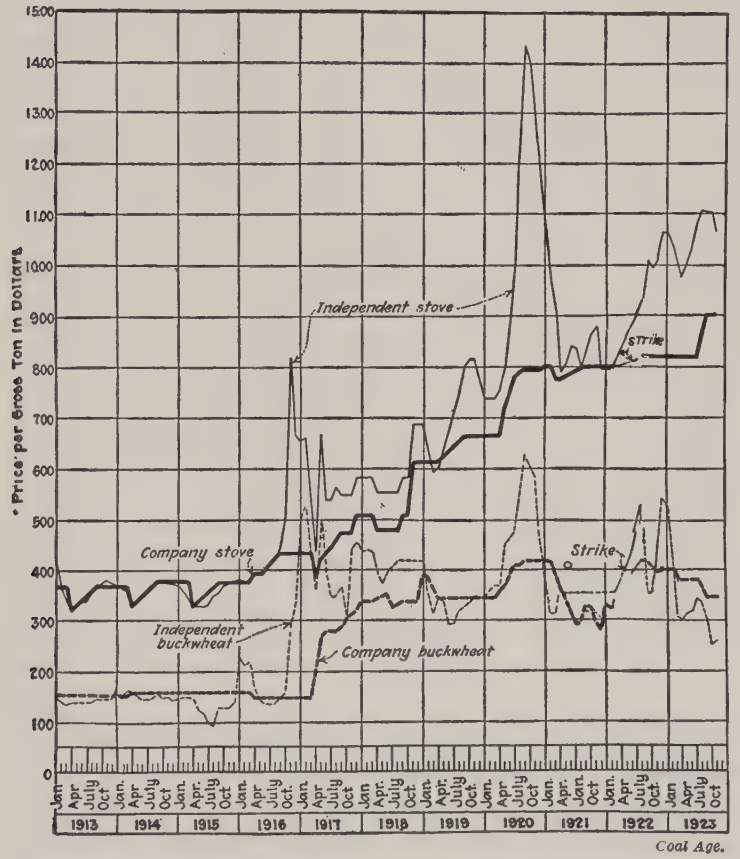


FIG. 52. Price range of anthracite coal during the past decade, f.o.b. mines per gross ton.

allowed on April 1 of each year, this being reduced ten cents each month until the full circular price was reached in the fall. As already pointed out, the idea of this reduction is to stimulate buying on the part of the householders

during the slack period in the summer, thus giving the mines better work and at the same time relieving the peak load in midwinter. It is a very commendable provision and has had a marked influence in stabilizing the trade.

Instead of a discount in 1916, the operators were forced by the increasing costs in all lines of labor and material to make an advance of twenty cents a ton to $3.95, which was followed by other increases, bringing the price up to $4.35 over the last half of the year. This price was continued until the following April, when the discount again went into effect only to be quickly wiped out with still further advances which brought the price up to slightly over $5 by the end of the year. The following year was a repetition of this and the beginning of 1919 found the price up to better than $6 per ton. No discount was attempted this year, the price advancing to $6.60 at the middle of the year, where it remained until April, 1920, when a very spectacular increase to $8 was made by the middle of the summer which was maintained until the following April. A discount of twenty-five cents was made in April, 1920, which was discontinued over the last half of the year, and the strike and increased costs in 1922 resulted in another advance to $8.25 in the first half of that year, to be followed by a still further increase of seventy-five cents as a result of the wage increases granted the miners in the first half of 1923, bringing the mine price of anthracite stove coal up to $9 per gross ton at the close of that year.

The steam sizes of anthracite, as quoted in the regular company circular, have also more than doubled in cost in the past decade, though all this increase has occurred beginning with 1917. During the four years previous to this, buckwheat coal sold at a practically uniform

price of around $1.70 per gross ton at the mines. Early in 1917, however, it began advancing rapidly, touching the $3.40 level at the year end and holding at this figure, with some minor fluctuations, through 1918 and 1919. Beginning at the end of the first quarter in 1920 there was another upward swing which carried the price up to $4.20 over the last half of the year, only to recede again through the first half of 1921 down to from $3 to $3.25, which was the price through the last half of that year. The market was not quoted during the strike period in the first half of 1922, but opened up in midyear at the $4 level, this price being maintained until the first of 1923, after which it gradually sagged off to around $3.50.

TIDEWATER MARKET

There is a very important, but at the same time unstable tonnage of bituminous coal moving into what is commonly known as the "tidewater trade", by which is meant coal dumped in vessels at the seaboard for bunker and export trade and distribution coastwise. This tonnage varies from around twenty-eight million (in 1922) to fifty-four million (in 1920), and about eighty per cent of this is dumped at New York and the Hampton Roads piers; the remainder moves through Baltimore, Philadelphia, and Charleston, the latter taking only one or two per cent. Practically all of this coal originates in Pennsylvania, Maryland, and West Virginia.

The wide fluctuations in the tonnage of Tidewater coal are due mostly to the erratic conditions in the export trade which is one of the legacies of the disturbances in trade resulting from the war. Our seaboard export trade has fluctuated in the last half dozen years from a million and a half tons to nearly twenty-two million tons a year, though these extremes were occasioned largely by a strike

in this country which limited the supplies available for export in the low year and a strike in Great Britain which created an abnormal demand for our product during the year of maximum exports.

The export trade of the United States, in terms of our trade as a whole and as compared with that of the other large producing countries, is relatively insignificant. Our maximum business in this direction amounts to only three per cent of our production, while that of Great Britain seldom falls below twenty-five per cent. Germany, before the war, was a close second to Great Britain and was increasing her export trade at a rate that would have put her in the lead in a comparatively short time; in fact, the German government declared this to be one of the chief reasons for Great Britain entering the war, a statement that is certainly substantiated by a review of the statistics, at any rate.

The poor showing of the American coals in the export trade is due to a number of causes. Great Britain, and Germany also before the war, are inherently trading countries, their economic existence in fact depending largely on their foreign trade. In the development of this trade they have established connections, not infrequently backed up with heavy investments and loans, that have given them a substantial advantage over other competitors less fortunately situated. Take for example the annual fuel contract of the Brazilian State Railways, a British-owned concern, the board of directors of which meets in London. It is more than likely that one or more British coal interests are represented on this board so that the prospects for furnishing American coal on this contract are negative.

The sixty-five or seventy million tons of British coal exports per year have also become an important if not a

vital part of her economic structure by assisting in maintaining the trade balance and in providing return cargoes for vessels engaged in the import trade. In addition to this the British coal exporters own and operate very extensive pier facilities and bunkering stations at the principal ports, which gives them an additional advantage over their competitors. And finally the American operators have generally failed to meet the more exacting requirements of the foreign trade in the matter of the preparation of their coal. With the exception of the anthracite field, the preparation of coal in this country is much inferior to that abroad, and our shipments in competition with those of Great Britain have often been a distinct disappointment to the buyers. There is little prospect that American coal will become much of a factor in the foreign trade, except in event of temporary shortages, until the European countries put restrictive measures on export shipments in order to conserve their fast dwindling reserves.

The bunker trade at seaboard absorbs from six to nine million tons of the Tidewater shipments under normal conditions, this business being somewhat more stable than the export trade. A very large tonnage, ranging from eight to eleven million usually, but sometimes exceeding fifteen million, is shipped to New England coastwise, this being one of the principal sources of supply for that section. Most of the export coal is dumped at the Hampton Roads piers, though Baltimore gets a certain amount of this business, Philadelphia a smaller portion, and New York practically none. All of the loading ports participate in the New England trade, though here again Hampton Roads is in the lead, shipping more than all of the others combined, with New York a poor second. New York and Hampton Roads together supply perhaps

ninety per cent. of the bunker coal, Baltimore and Philadelphia doing little business of this kind. In the strictly local trade, consisting principally of barge shipments to adjacent points, New York is substantially in the lead, more than half of her receipts going into this business. The receipts and distribution of coal at the leading Tidewater ports for the past several years are shown in Table 19 in the Appendix.

THE NEW ENGLAND MARKET

A distinctive feature of all the more important coal-consuming centers of this country is their location in the heart of the producing districts. Pittsburgh, the home of the iron and steel industry, Ohio, with its great manufacturing enterprises, the upper Mississippi Valley a combination of both the preceding, and Alabama, the Pittsburgh of the South, are all centered in the richest coal-bearing districts of the country. The one exception to this rule is in the New England States, comprising that section of the country lying to the east of New York State, with the exception of parts of Connecticut, which receives its coal supplies through the New York market. Here we have a relatively small but at the same time one of the most intensely industrialized sections of the country completely isolated from the coal fields. It is not only entirely separated from the producing districts but is limited to only two possible sources of supply, the Pennsylvania coals all-rail through the Hudson River gateway and coastwise shipments from the loading ports at seaboard, most of which coal originates at the Virginia piers.

The annual fuel requirement of the New England market at one time aggregated some eighteen to twenty million tons, though this has been reduced in the past few years by the introduction of various substitutes, fuel oil

alone having displaced some four million tons of coal. The remoteness of this section from the mining regions has made it very sensitive to market conditions, and consumers have suffered great inconveniences in times of inadequate supplies. As a result of these conditions, the buyers have been quick to adopt any means that would make them independent of the uncertainties in the coal supply. Water power has been developed more extensively, and there has also been a marked tendency towards the use of the more highly efficient central power plant. During an acute shortage occasioned by strikes at both the mines and on the railroads in 1922, there were also a million or so tons of British coal imported at Boston.

The Pennsylvania and West Virginia coals have held a dominant position in the New England market, their respective importance varying with the changing conditions in water and rail shipping, both as regards rates and reliability of service. The bulk of the Pennsylvania product arrives direct from the mines all-rail, but some tonnages find their way in by the water route from New York and Philadelphia, particularly the former. In normal times the West Virginia coals were more or less limited to the unloading ports along the seaboard, the Pennsylvania grades being the favorite with inland buyers; but the latter have been steadily crowded out in recent years, and their market is now largely confined to the relatively small territory west of the Connecticut River. Even here the West Virginia coals arriving by way of the rehandling wharves at New Haven and Bridgeport get a considerable volume of this business whenever trouble develops in the union districts of Pennsylvania.

The price of the New River and Pocahontas coals, loaded on cars at Providence or Boston for inland shipment, is now in the neighborhood of $5.75 per ton. This

would be on a basis of $4.50 at Hampton Roads, after making due allowance for shrinkage, rehandling charges, and water freights. The Cambria, Clearfield, and Somerset coals from Pennsylvania have fluctuated over a range of from $1.25 to as high as $12 per ton at the mine in the past decade, though this last figure was occasioned by a short panic during the boom period of 1920 and was of such a temporary nature that very little business was done on this basis. These coals sold with scarcely any variation at around $1.25 during 1913, 1914, and 1915, though a flurry in the market carried them up to $2.75 at the close this last year. During the first half of 1916 they reacted from this high figure to about the former level, but when the pressure of war business in the last half of that year became urgent they advanced rapidly to around $5, holding at this figure until the middle of 1917. The price then declined rather sharply to $2 per ton but again advanced by easy stages to $3 early in 1918, at which level it held with scarcely any variations until the violent increase in the second quarter of 1920 carried it up to $12 per ton. By the end of that year the price was down to $4 and the decline continued, culminating at the $2.50 level at midyear and continuing at this through the first quarter of 1921, when another sporadic increase carried it up to $7.75 temporarily. The beginning of 1923 found these grades down to $4 per ton, and the poor business in that year depressed them still further, forcing prices steadily downward to around $1.60 to $2 per ton, an increase of only fifty cents to seventy-five cents over the pre-war level.

THE EASTERN MARKETS

The Eastern market is commonly understood to include the State of New York, the western part of Pennsylvania,

including the Central Pennsylvania coal field, and the distributing centers along the Atlantic Seaboard, such as Baltimore, Philadelphia, and New York City. Considered as a whole, it has substantially the greatest consumption of any of the large individual markets. It is also one of the most intricate markets we have because of the great variety of coals entering into it, which has tended to make the business highly competitive. The very best grades of bituminous coals in the country meet and clash for supremacy in this market, so that it has developed the most discriminating classes of buyers there is.

This market draws on the two greatest bituminous coal-producing States in the country for its supplies, Pennsylvania with a production of a hundred million tons, and West Virginia with eighty million, though the latter is less of a factor than the former. A very large percentage of the Pennsylvania output goes into the Eastern and New England markets, including, of course, the Tidewater trade. The only districts not heavily engaged in Eastern shipments are the Pittsburgh, Connellsville, and the Butler and Mercer fields; most of the tonnage from these sections goes into Western Pennsylvania, Eastern Ohio, and the Lake trade, though a certain amount finds its way into the western part of New York State as well. Some of the more important coals originating in this State are: Clearfields and Somersets; Windber; Broad Top Mountain; Ligoneir; Greensburg, and Westmoreland

Northern West Virginia coals from the Fairmont, Phillippi, and Upper Potomac regions enter into close competition with the Pennsylvania grades in the rail trade, while nearly all of the southern West Virginia coals, including the New River and Pocahontas, Kanawha, Thacker, Tug River, and Logan County coals reach the

Eastern market by way of the Virginia terminals and come into competition at the seaboard ports.

The West Virginia coals are not, as a rule, much of a factor in the New York market, the Clearfield, Meyersdale, Greensburg, and Westmoreland coals from Pennsylvania being the general favorites. These coals are shipped into the Jersey terminals in large volumes and from there are distributed within the harbor limits in barges at a cost of from twenty-five cents to thirty-five cents per ton in normal times. There is also an extensive trade in this coal to near-by points such as Bridgeport, New Haven, New London, etc., and some shipments are made to Providence, Boston, Portland, and even to Bangor. Under normal conditions there are usually around two thousand loaded railroad cars standing at the Jersey docks ready for distribution in this trade.

New York City is essentially an anthracite burning community, having very strict antismoke ordinances prohibiting the use of bituminous coal for household purposes. With the gradual exhaustion of the anthracite supplies, however, it is doubtful if she will be able to maintain these regulations much longer; during the strike of the anthracite miners in 1922, it was necessary to rescind the ordinances temporarily and import some one hundred thousand tons of British coal a week for a time.

Assuming the cost of mine-run coal from the Clearfield district of Pennsylvania as typical of bituminous prices in the Eastern market during the past decade, we find that these have about doubled in that interval. The price of this grade on cars at the mine varied between the limited range of $1 to $1.25 per ton through 1913, 1914, and nearly to the close of 1915, when it made a spectacular advance to $2.60, though declining gradually through the first half of 1916 to a minimum of $1.20.

Another persistent increase over the last half of that year carried the price up to $4.50 at the year end. During the first half of 1917 it fluctuated between $4.50 and $5 or better, but declined sharply about midyear to a minimum of $2, though recovering to $2.50 in the last quarter. The first quarter of 1918 witnessed another advance to $3, at which level it held throughout the year. Another decline to $2.50 occurred in the first half of 1919 with another slow recovery to $3 in the last quarter. This price was maintained through the first quarter of 1920, when a very spectacular advance occurred that carried the price up to $11.25 at midyear, from which it gradually receded to the former level at the end of the year. The price declined persistently throughout 1921, touching a new low for the preceding five years at $1.80. Early in 1922 another spectacular upward movement started, culminating at $7.40 shortly after the middle of the year, when it again declined to $4, and in 1923 still further losses were recorded, the final price being around $2 per ton.

THE CENTRAL COMPETITIVE MARKET

This district includes the whole of Ohio, Eastern Pennsylvania, Northern West Virginia, and parts of the South, though these latter fields ship mostly to the seaboard market as already described. Kentucky coals are also an important factor in this market. This is a very intensively industrialized section, absorbing an enormous production. In addition, practically all the bituminous coal going into the Lake trade, amounting to from eighteen to twenty-two million tons per year, originates in this market. The field has many varieties of coal, competition is keen, and it is one of the most extensively unionized markets there is, the whole of Ohio and most of Eastern Pennsylvania being thoroughly organized.

The Pittsburgh district is one of the leading sources of supply in this market. Besides the famous Youghiogheny gas coals, it furnishes a large production from the Sewickley and Pittsburgh seams in the Connellsville region, most of which comes from along the Monongahela River, a great deal being shipped by water. The Connellsville region was singularly free from labor unions from 1891 till 1922, when the unions again effected a partial organization of the field, and it appears at this writing that it must now be classed among the other unionized fields. In the Pittsburgh district might also be included the coal from the Panhandle field, occupying the narrow upper extremity of West Virginia lying between Ohio and Pennsylvania. In times of a stress in the market, the Pittsburgh district draws heavily on all the West Virginia fields and even on some of the Kentucky mines on occasions.

The strong grip of the miners' union on the Ohio coal industry has introduced a very unstable condition in that market. In periods of a dull market the non-union operators of Pennsylvania and West Virginia have been able to cut wages sufficiently below the union scale to undersell the Ohio operator, so that the latter has had a rather precarious existence. The uncertainties of this market are reflected in the erratic trend in production for the State as a whole, the general tendency having been downward over the last half-dozen years. The Ohio coals are also generally inferior to most of the Pennsylvania and West Virginia grades, which has been another handicap to the operators. The only tangible advantage they have over competitors in other States is a closer proximity to the Lake shipping ports, giving them a slightly advantageous freight rate in this direction.

Slightly less than half of the Ohio production comes

from the Eastern or Number 8 field, a great deal of this being used locally at the steel mills in the Mahoning Valley and Youngstown. There are some very large coal-stripping operations in this section, producing from thirty thousand to sixty thousand tons of coal a week. The Panhandle region across in West Virginia also produces a great deal of strip coal. Cincinnati, Columbus, Cleveland, and the other Lake ports are the chief distributing centers. The first is an important gateway for West Virginia and Kentucky coals into Ohio, the Middle West, and even up into the Northwest. Columbus is a distributing point for both Ohio and West Virginia coals, and Cleveland consumes some five million tons locally in addition to that transshipped in the Lake trade.

The Northern West Virginia fields produce twelve to fifteen million tons a year, a substantial part of which is a factor in the Central Competitive district, though this has been reduced considerably in recent years by freight differentials more favorable to other districts. In 1914 this district was shipping over five million tons a year to the West and in the Lake trade, whereas there is now something less than a million tons going in this direction. Coal is moved out of the northern field over the Baltimore and Ohio, Western Maryland, and the Monongahela River lines, the latter taking some four million tons a year which it turns over to the Pennsylvania and the New York Central roads.

The price of Hocking Valley mine-run coal in this market a decade ago seldom varied from somewhere between $1 and $1.25 per ton on cars at the mine. The first important change from this level was about the middle of 1916, when a very spectacular upward swing carried the price to $4.75 in two or three months. The price was somewhat unsettled at this level and started declin-

ing irregularly early in 1917, touching $2 in the last quarter of that year, but reacting to $2.50 before the year end. There was scarcely any change from this price through 1918, but a gradual decline started the first of the year following, culminating at the $2 level about midyear though another advance restored the $2.50 price once more before the end of the year. Another very spectacular advance at the end of the first quarter in 1920 carried the price up to $7 per ton by midyear, but after fluctuating uncertainly at this level for a few months there was an equally sharp decline back to $2.50 at the end of the year. A persistent though gradual decline through 1920 and into the first quarter of 1921 carried the price down to $1.80, when another very rapid increase occurred, touching a maximum of $5.75 by the middle of the year, from which it receded to below the $3 level over the last half of the year, and by the end of 1923 it was down to $2 per ton or less.

THE WEST VIRGINIA MARKETS

The discussion of the coal markets is commonly centered around the chief distributing centers, instead of the mining districts themselves. In the case of West Virginia, however, it is necessary to depart from this procedure for several reasons. Because of the peculiar excellence and great variety of these coals and their strategic geographical location, they have an extraordinary distribution, second only to that of the anthracite grades. The West Virginia coals have been permanently established for many years in practically every market from New England to the Northwest. With the exception of some parts of the Tidewater trade on the Atlantic Seaboard, they cannot be regarded as a dominant factor in any of these markets, and even there they are subject

to extraneous influences due to fluctuations in the foreign markets, vessel freights, etc. It is obvious, therefore, that no one of these markets can reflect the average conditions existing within the West Virginia trade itself and it becomes necessary to treat this as a separate element.

The northern West Virginia field has already been discussed in connection with the Pittsburgh district, to which it is naturally tributary. The balance of the State is commonly divided in the trade parlance along two broad lines designated as the high volatile and the low volatile or smokeless fields. The high volatile field lies in the extreme southern part of West Virginia and includes parts of eastern Kentucky and southwestern Virginia. The principal producing fields in West Virginia are the Logan, Kanawha, and the Kenova-Thacker districts, which together output some twenty-four million tons of coal annually; about half of this originates in the Logan field and some six million tons in the Kenova-Thacker district. Virginia produces around nine million tons of high volatile coal per year.

The low volatile coals are all produced in the Pocahontas, New River, and Winding Gulf fields, the combined production of which is in the neighborhood of thirty million tons a year, the Pocahontas field producing about eighteen m llion and the remainder divided equally between the New River and the Winding Gulf fields. The great superiority of these coals is recognized in all the coal markets of the country and has been treated at length in the section describing the coal fields. Besides their unrivaled position in the steam coal trade, they are now coming into very general use as a substitute for anthracite in the domestic trade and are also finding a wide application in the by-product coke business.

The West Virginia operators might be quite properly termed the pirates of the coal trade, standing ready at all times to descend on any fat prize that may appear on the horizon. Let a shortage of fuel appear in the Northwest or in New England and the West Virginia producers will soon be on the job with their high-grade coals gobbling up the main plums, much to the chagrin of the Illinois or Pennsylvania producers, as the case may be. For the Ohio mines, handicapped by somewhat inferior coals and union scales, they have an indifference bordering on contempt; in times of a dull market the West Virginia mines have only to reduce their wage scales, a matter the miners are not liable to protest when work is slack, and they can put their high-grade coals down in the heart of the Ohio mining districts cheaper than the local mines can produce it themselves.

We thus find the West Virginia operator following the trend of the greatest market opportunity. When the world conditions are favorable to a heavy export trade he is concentrating his efforts in that direction, allowing his competitors a meager benefit therefrom by his partial withdrawal from other markets. In the dull summer period he ships through the Ohio mining districts and absorbs the bulk of the lucrative Lake trade, and in the winter he devotes his energies impartially to any market showing evidences of distress. Being non-union, he waxes exceeding fat on the abnormally high prices created by the shortages incident to the strikes in the union fields. These are the reasons that West Virginia has forged to the front so rapidly in the bituminous coal trade of the country.

The price of the West Virginia smokeless coals for a number of years previous to 1916 seldom ever exceeded a maximum of $1.40 per net ton for mine-run coal on cars at the mine, nor did it ever quite touch a minimum

of a dollar. About the middle of that year, however, the pressure of the war demand for coal created a strong upward movement that carried the price up to better than $5 per ton by the end of the third quarter, where it remained with some fluctuations until about the middle of 1917. A very rapid decline then occurred, culminating at the $2 level but followed by a recovery to $2.50 before the end of the year. This price held, with some minor fluctuations, through 1918, followed by a gradual advance through the first three quarters of the following year to slightly better than $4, though another rapid decline carried the price down to $2.40 at the beginning of the last quarter. This level was continued through the first quarter of 1920, when a very spectacular increase, occasioned by the industrial boom and lack of government regulation, skyrocketed the price up to slightly under $13 per ton. A more gradual decline carried the price down to $2.75 by the first quarter of 1921, the decline persisting throughout that year and culminating at $1.75 in the first quarter of the year following. Another irregular advance then occurred up to $6 per ton but followed by a subsequent decline to around $4.50 at the end of the year, with additional declines through 1923 that carried the price down to around $2 per ton at the end of that year.

THE SOUTHERN AND MIDDLE WESTERN MARKETS

In point of territory involved, and excluding the Western or Rocky Mountain market, the commercial tonnage of which is comparatively insignificant, this is substantially the largest coal market there is. It might quite properly be subdivided into several distinctive sections as the Illinois and Indiana product seldom encroaches into the sphere of the Alabama coals, though non-union coals from the latter are a factor in the Middle Western

trade when there are labor troubles in that district. However, the lines of demarcation are so vague and the whole so inextricably tied together in several competing territories that they cannot be well separated.

The Chicago district is sometimes referred to by the more optimistic members of the local trade as "the world's greatest coal market", a title which Pittsburgh and some of the Seaboard distributing centers would no doubt dispute. However, it is none the less a fact that something over a hundred of the larger Middle Western producers have their headquarters there and that a very large tonnage and great variety of coals are dealt in there. The local consumption absorbs a very considerable amount of coal and in addition to this it competes aggressively in the Northwest territory with Eastern coal arriving at the Upper Lake docks by the water route.

Chicago and St. Louis are the two principal distributing centers for the Illinois and Indiana coals. A peculiar characteristic of the Illinois coal fields is the almost uniform improvement in quality with the increased distance from Chicago, those of the northern section being of a noticeably inferior quality as compared with the product from the southern mines. In fact the southern coals have acquired such a reputation that operators on the outskirts of this field have consistently protested any attempt to define any limits to this field which does not include them.

The Illinois coals are commonly quoted in the Chicago market as Southern, Central, and Spring Valley. The Indiana product is divided into two grades known as Fourth and Fifth Vein, the former being of the best quality. Various grades from West Virginia and both East and West Kentucky coals are also a constant year-around factor in the Chicago market.

In Southern Missouri, Arkansas, Louisiana, and Texas the Illinois coals come into competition with the Kansas, Oklahoma, Arkansas, Alabama, and Western Kentucky grades. The Arkansas coals also get into Kansas City and St. Joseph, and the Alabama cokes are beginning to compete with Pennsylvania anthracites at St. Louis, while West Kentucky coal sometimes arrives there in barges when there is a tight market. Fuel oil is making heavy inroads throughout this territory, having displaced some seven hundred thousand tons of coal a year in the Kansas City market alone. West Virginia, Tennessee, and even Colorado coals have been brought into this market for emergency purposes, and barge coal from West Virginia is a regular factor in the Louisville trade.

The non-union fields of Alabama, with a possible production of nearly half a million tons per week under favorable conditions, are always an important factor in the Middle Western market when there are labor troubles. The production of this State is normally around fifteen million tons of coal and three to four million tons of coke a year, but with a plentiful car supply, such as is available when the union mines are closed down, the rate of production is capable of a very material expansion. A considerable portion of this coal goes into the bunker and export trade also, particularly since the recent improvement in navigation on the Warrior River and the docks at Mobile.

The price of Southern Illinois mine-run coal for several years previous to 1916 varied between $1 and $1.20 per ton on cars at the mines, but in the last quarter of that year it advanced very rapidly to $3.20. The following year was one of rapid and wide fluctuations, the price declining to $2 in the first quarter but recovering to $3.10 at midyear. A more gradual falling off in the last half

carried the price down to $2 once more, followed by a partial recovery to around $2.40. This level was maintained, with minor fluctuations, through 1918, 1919, and the first quarter of 1920, when a very strong spurt carried the price up to $7.50 shortly after the middle of the year, followed by an equally violent decline down to $3 at the end of the year. The price fluctuated erratically around this level throughout most of 1921, softening towards the end of the year and closing at $2.50. Another upward swing occurred in 1922 that touched $4.75 by mid-year, from which there was a gradual decline to $4 at the end of the year, followed by further declines in 1923 that brought the price down to around $2.50 at the end of that year.

THE NORTHWESTERN MARKETS

The Northwestern market includes Wisconsin, parts of Iowa, Michigan, and Minnesota, the Dakotas, and some points farther west, as well as a large strip of Canadian territory along the adjacent border. Since about three fourths of the coal shipped in the Lake trade goes into this market it is proper that this be discussed under this heading as well. Excluding the iron and copper mining regions, there is not an extensive demand for steam coals in this section, but the territory covered is large and more or less densely settled, and the rigorous winters create a high per capita consumption of domestic grades.

The distribution of coal to the various Lake ports for the past several years is given in Table 20 in the appendix, in which it will be noted that from eight to fifteen million tons of coal a year are shipped to Lake Superior ports, all of which go into the Northwestern market. In addition there are some six or seven million tons shipped to Lake Michigan ports, all except about a million and a

half tons of which goes to ports on the West shore and thus finds its way into the Northwestern market also.

All the bituminous coal is shipped from Ohio ports on Lake Erie, with the exception of a small tonnage from Erie, Pennsylvania, and the anthracite is loaded at Buffalo. Toledo is substantially the most important shipping point, with Ashtabula and Lorain next. The Lake shipping is confined to the season of navigation, beginning in April and ending in December with comparatively small tonnages being moved in these two months. The total capacity of all the loading ports under favorable conditions is close to a million and a half tons a week.

Receipts at the head of the Lakes, Duluth and Superior, are normally between eight and ten million tons, and the docks there are equipped with some of the most modern types of unloading machinery for insuring rapid discharge of the carriers so there will be the minimum of delays. This coal can be loaded direct into railroad cars for shipment or placed in storage as may be required, and there are times when nine thousand railroad cars a month have been loaded out from these docks. The docks usually have five to six million tons of coal on hand when the Lake shipping season closes, for distribution during the winter months.

The Lake trade has been built up almost entirely within the last two decades and is due largely to the efforts of the larger Eastern bituminous companies who were driven into it to obtain an outlet for their summer production. The dock companies are nearly all owned or controlled by the operators of Ohio, Pennsylvania, or West Virginia and are really sales departments of these companies. The Pittsburgh Coal Company, for instance, has extensive dock facilities, and the Northwestern Fuel Company, another large operator, is a subsidiary of the Consolida-

tion Coal Company. Some of these companies have also engaged in the retail trade. At Duluth-Superior the dock companies handle about sixty per cent. of the anthracite retail trade and from forty to sixty per cent. of the bituminous, the balance being handled by some twenty large independent retailers with rail coal from the East and Middle West.

Some four million tons of anthracite coal a year are shipped in the Lake trade under normal conditions, of which the Duluth-Superior docks take about two million, Milwaukee one million, and the balance is distributed to various other Lake ports. When the anthracite receipts by Lake are inadequate, the deficiency is made up in part by rail shipments, though coal routed in this way is somewhat more expensive.

Practically all of the Eastern coals are represented at the docks, the Pocahontas grades commanding the best price, with the splint coals next, and the Youghiogheny and Hocking Valley the last. These coals are at their best in the immediate vicinity of the docks, competition with the rail coals from the Middle West becoming sharper as the freight differential in favor of the latter becomes more advantageous in the interior. Northern Michigan, Wisconsin, and Minnesota are largely controlled by Lake coal. Middle Western and Lake coals clash in Southern Wisconsin, and Minnesota, south of St. Paul. Minneapolis is an important center of the rail shippers into the Northwestern territory, many of the operators maintaining offices there and sending representatives out into the surrounding competitive country. The Iowa and North Dakota lignites are a factor in the local trade in some sections, and in Eastern Montana the coals from that State and Wyoming shut off any further Western extension.

THE WESTERN AND PACIFIC COAST MARKETS

In this great territory, equalling perhaps one half of the combined area of all the other coal markets, we encounter conditions of a very distinctive character. The density of the population is substantially below that in any other part of the country, so that the domestic requirements, as compared with those in the eastern part of the country, are practically negligible. The industrial and manufacturing enterprises that absorb such an important part of the Eastern coals are either totally lacking throughout the West or concentrated in a limited number of large units that have been forced into coal mining themselves to protect their supplies.

Coal mining as a distinctive business in the West has not reached the stage of development represented by the large independent mining companies of the East for several reasons. The principal one of these is the limited market and the large initial investments and financial hazards involved. The western Cretaceous coals are lacking in the remarkable uniformity that is characteristic of the eastern Carboniferous measures, and if it were possible to prepare a statement of profits and losses in the coal-mining industry of the West up to the present time, it is more than likely that the final summary would show a deficit. Thus we find that the principal consumers have been literally forced into the production of coal to assure themselves adequate supplies, and they are the dominant factors in the trade.

The large transcontinental railroad systems are the first and most important producers. The Union Pacific has extensive operations in the high-grade fields of Southern Wyoming and has been endeavoring for a number of years to develop a source of supply on the Pacific Coast.

The Great Northern and Chicago, Milwaukee, and St. Paul roads operate in Montana and the Northern Pacific both there and in Washington. In the industrial and metallurgical field, the Colorado Fuel and Iron Company dominates the trade in Colorado, with the American Smelting and Refining Company the most important producer to the south, and the Anaconda Copper Mining Company to the north.

Development of the western coal industry has also been much handicapped by the growing use of substitutes. The rapid mountain streams of the Rocky Mountains afford unusual opportunities for the economical development of hydro-electric power which the railroads and mining companies of the Northwest have gone into extensively. The California and Texas oil fields have encroached on the markets from both of those directions and additional discoveries have been made in Wyoming and Montana which may eventually become a factor in that section.

Coals in the New Mexico field, besides being used locally, find their way into Kansas, Texas, Western Oklahoma, Arizona, and California. Colorado coals are shipped into Nebraska, Kansas, New Mexico, Texas, and Oklahoma. The Colorado fields are unorganized, so that they also become a factor in the Wyoming fields when there is trouble in the closely unionized sections of that State. The eastern lignites in Wyoming are shipped into Montana, South Dakota, Nebraska, and Western Iowa, while the southern bituminous coals have a somewhat wider distribution, reaching into Idaho, Montana, Oregon, and Washington to the west, Colorado and Utah to the south, and Nebraska to the east. The Montana coals are shipped into North and South Dakota to the east and Washington and Idaho to the west. The Washing-

ton coal fields compete some with the Montana fuels from the east, but find their chief market within the State, shipping some to California to the south and Canada to the north.

PART FOUR

ECONOMIC AND SOCIOLOGICAL CONDITIONS

CHAPTER I

Cost of Coal to Consumer

In the preceding section we have already given a more or less detailed analysis of the wholesale price of coal at the chief distributing centers of the country during the past decade or more. These prices have been on a uniform basis of the cost at the mine in carload lots and represent the market fluctuations that have prevailed in the case of the comparatively large-scale consumer, the wholesaler, and the retailer. A study of the retail prices to the average householder introduces additional cost factors such as freight rates, brokers' and retailers' profits, handling and distributing costs, etc.; these factors have fluctuated as much as the cost of the coal at the mine, and being an integral part of the ultimate cost of the coal in the householders' bin, they must be scrutinized with equal care.

In a present-day study of costs of any commodity it must first be accepted as axiomatic that beyond doubt there has been a very material increase. The consumer now pays two or three times the price for his material requirements on nearly everything from his newspaper up that he did a decade ago. While now somewhat calloused to this phenomenon and more than ordinarily absorbed in endeavoring to increase his income to meet these mounting costs, he is none the less keenly resentful of exorbitant prices savoring of profiteering. Unfortu-

nately the coal industry has been a favorite object of attack for practices of this description engendered, perhaps, by some occasional well-authenticated examples, so that there is a deep-rooted and widespread suspicion of the industry as a whole. It was to the recognition of this feeling in all parts of the country that we owe the creation of the U. S. Coal Commission, which has just recently completed its voluminous investigations. The officials responsible for this determined upon the course with the view of either clarifying the atmosphere or correcting any inherent evils that might be uncovered.

In all essential respects the Commission has given the coal industry a clean bill of health. It has effectually disproved the theory of any deep-laid conspiracy to exact exorbitant profits and it has failed to uncover anything fundamentally wrong within the industry, for which it was prepared to suggest a remedy. The report, appearing over the signature of the eminent personnel of the Commission, will be a potent influence in restoring public confidence in the industry as a whole. It has, further, put the stamp of authority on certain recognized evils which, in the words of Secretary Hoover, has made the coal business "the worst functioning industry in the country." And in doing this it has made the first move towards initiating the necessary reforms for correcting these evils.

Viewing the matter of coal prices in its broader aspects over the past history of the coal industry, the consumer has had little to complain of until within the last decade or less. Previous to this time the cost of coal has scarcely held its own in the constantly rising economic scale. This was due in part to a ruthless competition and large overdevelopment and also to the very excellent operating methods and rapid adoption of labor-saving devices by the operators. Thus the increase in the cost of coal has

not been in consonance with the steadily increasing costs in labor and material, until the acute shortages developed by the abnormal war demands began to make their appearance.

During the past decade, however, we have had the unpleasant experience of absorbing a hundred per cent. increase in the cost of coal. The increase is not out of line with advances in other commodities raised to abnormal levels by the unstable economic conditions. But where these others reached their peak and have been reacting in the past several years to more normal levels, coal prices have been more or less persistently maintained, the anthracite grades having even been increased to new high levels as late as 1923. It is, therefore, of interest to look into the conditions leading up to this apparently inconsistent action in the matter of coal prices over the past decade.

ANTHRACITE COSTS

The wholesale price of the domestic grades of anthracite coal on cars at the mine over the past decade has already been discussed in some detail in the preceding section. We have shown there where the price of stove coal has increased from around $3.50 up to between $8 and $8.50. According to the U. S. Coal Commission the average retail price for this same grade, per short ton, delivered at the customer's curb in Boston, has increased from $8.25 in 1913 to $15 in 1923; in Washington, D. C., the increase over this same period was from $7.50 to $15.39, though this latter was on a long-ton basis.[1] The price of this

[1] The reader is again cautioned to distinguish between the long (2,240 pounds) and the short (2,000 pounds) ton. See remarks on p. 37. The Commission has apparently used the two indiscriminately, thereby upsetting their value in a comparative sense, but it has been deemed advisable to adhere to their figures rather than chance misquoting them.

grade of coal at some of the chief distributing centers in November, 1922, all on a short-ton basis, was as follows: Boston, $15.68; New York City, $13.77; Philadelphia, $12.93; Washington, $14.20.

A very detailed analysis of the distribution of these costs was also made in which it was found that from forty-five to sixty-one per cent. accrued to the producer. The smaller percentage was naturally to the higher-cost and more remote sections where the freight burden was excessive, such as Boston, and the higher percentage to the more contiguous markets such as Philadelphia. The transportation cost, of course, varied in a similar way, amounting to sixteen per cent. at Philadelphia and twenty-three per cent. at Boston. The percentage to the dealer to cover distribution charges, together with his profit, varied from twenty in Washington to thirty-two in Boston. The actual profits accruing to the various interests in the course of these transactions is estimated at eleven per cent. of the delivered price, of which four goes to the retailer and seven to the producer and wholesaler.

Wide variations in the dealers' methods of doing business, as shown in the part on the Distribution of Coal, have resulted in equally wide variations between his cost and selling price. The dealer who operates *sans* equipment of any kind, hand-shoveling the coal from a railroad car on the siding, will be facing excessive labor costs. In the modern well-equipped yard the coal will be handled mechanically, thereby reducing the cost for labor but introducing an additional cost for interest on capital, depreciation, and repairs to equipment. As a result of these conditions the Coal Commission found that the margins between the retailers' cost and the price to the consumer varied from $1 to $3.50 or more.

A study of the dealers' operating costs, expenses, and

profits in five of the larger cities during a three-year period showed that the profits varied irregularly from twenty-nine to forty-nine cents per ton. Expenses during this interval were between $1.99 and $2.39 and the gross margin between the cost and selling price varied from $2.41 to $2.88. Reports from different sections of the country indicate that this margin has increased a dollar or more with some dealers during the past five years.

About eighty per cent. of the anthracite domestic sizes are sold directly from the mines or through sales agents and the remaining twenty per cent. through wholesalers. The margins of these latter average around twenty-three cents to twenty-seven cents per ton but vary over a wide range from six cents to as high as $1.40. The anthracite wholesale dealer is, however, sometimes required to dispose of certain tonnages of steam sizes on which he may sustain a loss so that it is difficult to arrive at a fair estimate of his net profits.

Transportation costs on anthracite coal, involving from sixteen to twenty-three per cent. of the ultimate cost of the coal to the consumer, are admittedly high, in view of the class of service rendered. It has been a recognized fact for many years that the anthracite traffic is the backbone of the hard-coal roads, and the Interstate Commerce Commission has wrestled with the problem of introducing more equable tariffs for a long time. The mining and operating interests are, however, so inextricably tied together either by direct or partial ownership, or through interlocking directorates, that it has been an exceedingly difficult problem to untangle. The chief difficulties have hinged around an intricate system of compensating for losses in mining by increased profits in transportation. It appears at this writing that a very definite and final segregation of the mining and transportation interests is

now about to be achieved and this would again open up the question of freight tariffs and clear the way for a readjustment of the rates by the Commission.

An analysis of the production costs at mines outputting around sixty-five per cent. of the total anthracite production shows that these have increased from $2.23 per ton in 1913 to $5.75 in 1923. The increases were along consistently moderate lines until 1918, when there was a very sharp advance of a dollar per ton followed by approximately similar increases in 1919 and 1920. Labor costs increased during this interval from $1.56 in 1913 to $4.12 in the first quarter of 1923, the proportion of this to the total cost continuing at about seventy per cent. The cost of material and supplies increased from thirty-five cents to seventy-one cents per ton, the proportion to the whole being somewhat less in 1923. General expenses increased from thirty-two cents to ninety-two cents, the relative increase being higher.

The margins to the operators show a very large increase during this period. During the four years previous to our entering the war, the average margin of the railroad coal companies was thirty-seven cents per ton. In the years 1919 to 1921 it was sixty-one, fifty-six, and eighty-five cents respectively, the variations being due to price changes and in part to moving the steam sizes in and out of storage. The five months' strike in 1922 occasioned heavy losses to the companies, but in the last quarter of that year, when operations had been resumed, the margins jumped to $1.15 and in the first quarter of 1923 they were $1.18 per ton. This rapid gain was due to a slight increase in the price of domestic coal and to a very strong market for the steam grades which resulted in a material increase in the profits on these sizes. In comparing these later margins with those previous to the war, a deduction

of around eleven cents per ton should be made to cover federal income and excess-profit taxes which were formerly comparatively negligible.

It must be remembered that while these figures may be accepted as the approximate average for the industry, there is also a wide margin between the high- and low-cost operations, some of the former scarcely showing a reasonable return even at the high figures. This opens up the very broad and significant question of conservation, which is discussed in a separate chapter farther on. The higher margins must inevitably enhance the value of the coal lands to the operating interests and stimulate efforts towards effecting recoveries that would not otherwise be possible, and a reduction in the margins may quite possibly result in abandoning certain collieries, involving the loss of very considerable tonnages of coal that in the interests of conservation should be recovered.

Of the inherent evils in the marketing of anthracite coal, the one of pyramiding profits by multiplicity of sales among the brokers and wholesalers themselves in times of a shortage has been the subject of the most complaint. While the spectacular features of these transactions have occasioned deep resentment, they are not, in the final analysis, an important consideration in the average price of the coal to the consumer because of the relatively small tonnages involved. However, it is an abuse that should be corrected if possible.

In the winter of 1922–1923, the Coal Commission traced some seven hundred and fifty cars of the domestic sizes of anthracite coal shipped into the New England market with a view to ascertaining the extent of this evil during a period of straitened market conditions. It was found that nearly half of these cars passed through the hands of more than one wholesaler or broker, while some were resold as

often as four times, before getting into the hands of the final consumer. The margins on the coal passing through only one broker varied from 20 cents to $3 per gross ton, with the majority ranging from 50 cents to $1.25 per ton. Where the coal passed through more than two hands the total margins varied from 25 cents to $4.75. Total margins where three jobbers were involved ranged from 68 cents to $4.03, and where the coal passed through four jobbers the total margin ranged from $1 to $2.25.

In addition to these abuses it was also found that some companies were resorting to unsavory subterfuges to defeat the spirit, if not the intent, of the regulations laid down by the Pennsylvania Fair Practices Committee which had been organized to combat the threatened high prices. Thus, some companies shipped the brokers at the prices fixed by the Committee but with an understanding that they were to benefit in any premium that the wholesaler realized on the sale of the coal. Other companies shipped to individuals, sometimes officers in the company, who resold the coal outside of the State at the existing high levels and refunded the extra money to the company.

As already pointed out the tonnage of high-priced coal moving along these lines is comparatively negligible, so that these practices have not had the important influence on the average price of anthracite coal that they are commonly credited with. They have, however, stimulated a distinctly adverse sentiment against the industry as a whole, and a continuation of these methods will most certainly bring down the wrath of the public and result in drastic regulation.

BITUMINOUS COSTS

The abundance of the bituminous coals has made this business of a highly competitive character, eliminating, in

a large measure, the possibility of the evil practices that have marked the anthracite trade. A strike in the latter field means a complete cessation of supplies and a consequent opportunity for wild speculation, since the anthracite coals are a very specialized fuel for which there is no satisfactory substitute. On the other hand, there is no possible contingency whereby all of the bituminous supplies could be cut off simultaneously; only a portion of the soft coal mines are unionized, so that a strike means but a partial reduction in the production and though some consumers may have difficulties in obtaining grades from other fields that will meet their special requirements, the condition is not at all comparable with the difficulty in seeking a satisfactory substitute for anthracite.

In addition to this the anthracite coals are a more or less purely domestic fuel so that high prices and shortages affect the public interest quicker and more surely than in the case of the bituminous grades, which belong more to the class of industrial fuels. A thousand tons of anthracite would perhaps suffice to quiet the protests of a hundred householders where an equal tonnage of bituminous would meet the requirements of only one moderate-size steam consumer. The latter is also buying more directly and with a more intimate knowledge of just what proportion of his money is going to the producer, railroads, wholesalers, etc., and where, if any, extortionate profits are being exacted. The household purchaser of the anthracite domestic grades, on the other hand, has no access to information of this kind and no redress for the adjustment of his wrongs except the retail dealer, whom he strongly suspects and who in all probability is the least guilty of any of the factors concerned. The psychological effect of these conditions has, therefore, tended to create less interest and public concern in the matter of bituminous

prices than it has in anthracite. There appears to be a general realization and acceptance of the fact that the bituminous trade is more closely competitive and affords less opportunity for exacting extortionate profits than is the case in the hard-coal industry.

The prices of bituminous coal in this country have generally averaged less than in any other coal-producing country in the world. It is particularly significant to note that for the quarter of a century preceding 1915, the general tendency of soft-coal prices has been downward, and this in the face of constantly rising costs for both material and labor. This result has been achieved by the extensive application of mining machines and other labor-saving equipment, and during this same interval the cost of fuel in the four other chief coal-producing countries more than doubled.

Specific costs of bituminous coal at all of the chief distributing centers have already been covered in detail in the chapter on The Coal Markets. To these costs the reader who is interested in the price of coal from a certain district can add the various supplementary charges, including the wholesalers' and dealers' profits, delivery and transportation costs, etc., as enumerated for the anthracite coals in the preceding section and obtain the cost of any bituminous coal he may desire. For the purpose of general reference we are also giving in Figure 53 a graph from *Coal Age* showing the average spot price of bituminous coal per net ton at the mines for the years 1906 to 1923 inclusive. The last ten years of this diagram is predicated upon the weighted average price of fourteen bituminous coals as quoted in that journal, representing different fields producing ninety per cent. of the bituminous output. The balance of the diagram was compiled by members of the statistical department of the U. S. Geologi-

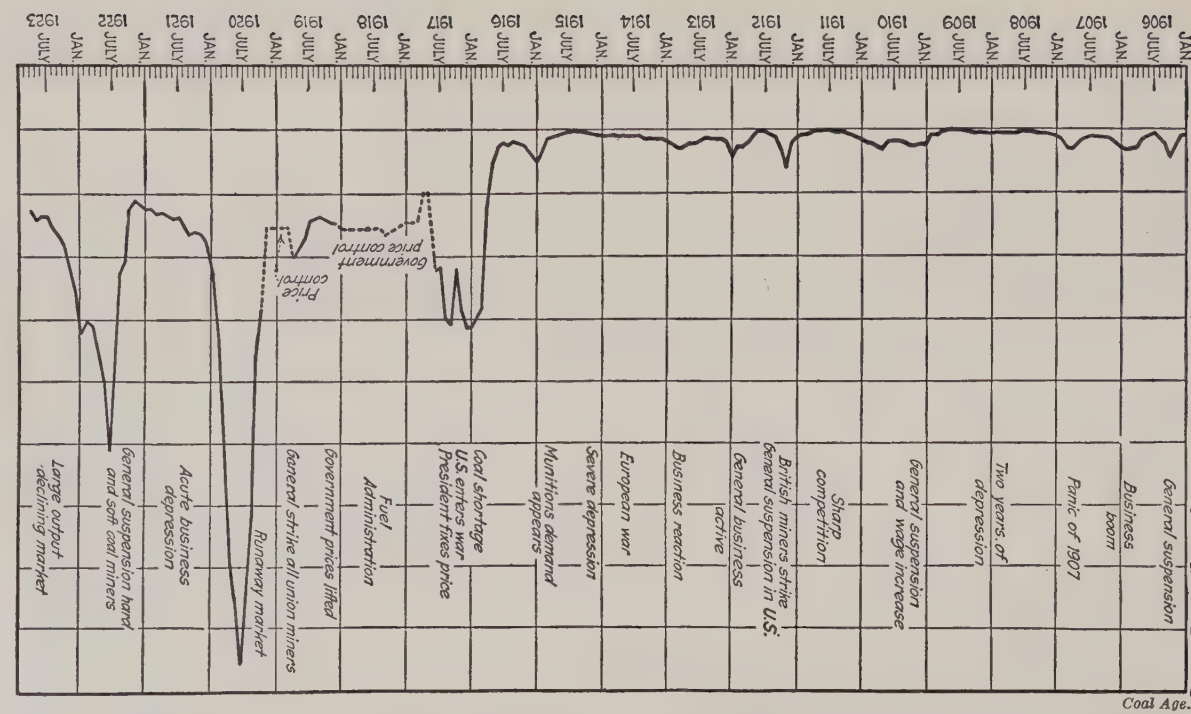


FIG. 53. Chart showing the weighted average price of bituminous coal in the United States per short ton f.o.b. mine for the 18 years from 1906 to 1923 inclusive.

cal Survey after a painstaking research of the old files of the trade journals, care being taken to use coals that would be comparable with the remainder of the diagram. The resulting curve probably represents as close an approximation to the average price of bituminous coal over the past two decades as it is possible to make.

CHAPTER II

Value of the Coal Industry

Economists who have endeavored to arrive at a reasonable valuation of the coal industry as a whole find themselves confronted with two conflicting schools of thought between whose merits it is difficult to choose. On the one hand we have the corporate interests endeavoring to show enhanced capitalization accounts in order to make any excessive returns on the investment appear reasonable. As an example of this a number of the anthracite companies are carrying coal lands on their books at a greater value than when these were acquired, though more than a third of the coal has been exhausted. The other school, working for a reduction in costs, takes the position that the capital accounts must be computed on the basis of the actual cost, a figure that it is now impossible to ascertain in the case of many companies, notably the older anthracite corporations.

The U. S. Coal Commission refused to commit itself to either side of this controversy, declaring it to be an issue for the courts to adjudicate. In this connection the Commission points out the similarity of the coal industry to the public utility which the courts have been called upon to value for the purpose of fixing equable rates. The courts have in these cases considered the original cost of the properties, stock and bond issues, and the cost of reproducing at the present time, reserving to itself the preroga-

tive of determining the weight to be accorded to these various elements.

The accepted method of valuing a mining property, as practiced in financial circles, is on the basis of the present and future earnings. It is a comparatively simple matter to compute the remaining recoverable tonnage in a developed coal property and, knowing the profit per ton, the present-day value can be determined with reasonable accuracy. The Commission properly objects to this basis of valuation as applied to the anthracite mines for the reason that the current profits are predicated upon monopolistic conditions. An estimate of the value of the properties on this basis would obviously disregard the question of whether the anthracite companies were taking advantage of these peculiarly monopolistic powers to exact unreasonable profits from the public.

VALUE OF THE ANTHRACITE INDUSTRY

The U. S. Coal Commission had prepared for it by a voluntary committee of engineers a detailed analysis of the probable worth of the anthracite coal industry. This committee served without compensation and was composed of some eminent experts with special experience in the appraisement of coal-mining properties. Their report was not officially accepted by the Commission, though it was made a part of the record of their investigations.

This committee considered the various methods of arriving at a reasonable value, including actual cost, assessed valuations, sale value, royalty valuation, and tonnage value and rejected all of these in favor of the plan of computing the total capitalization on the basis of the estimated future earnings. As authority for this method of procedure they quoted Finlay and Hoover. The method, therefore, was based on the present value of operating

properties, including all available coal. The term "available coal" was construed as indicating coal that would be mined within the next forty years, the balance of the holdings being considered as reserves.

In the preparation of this report the committee predicated the prospective future earnings on the weighted average results for the years 1920–1921 in general, though taking other periods where these were not available or were misleading. The production costs used did not include royalty, depletion, depreciation, and interest charges; the first two represent the value of undeveloped coal lands, depreciation the value of the improvements and interest charges, and profits the returns to the capital used in operation. Federal taxes were charged against income and deducted from the realization. Future tonnage was estimated after consideration of the past tonnage and of the reserves in each district. From the data thus obtained the value of the operating properties was determined by discounting at six per cent. compound interest the net annual returns, as a varying annuity estimated for each field and for the period noted, the latter obtained by applying the values as above indicated, per ton, for the estimated tonnage for each year.

The difference between the operating tonnage as previously outlined and the total estimated tonnage of each of the major fields was put into the reserve tonnage. This was considered as a whole in each field as undeveloped coal and valued on the basis of actual sales or on existing royalty rates, but considered deferred for the life of the operating lands. The total valuation then consisted of a summary of the reserves and operating lands, including development and equipment.

The committee found that the average royalty paid on all coal sold was 16.5 cents per ton and the average deple-

tion charge 14.7 cents, while the average depreciation charged on the plant was 10.8 cents. Valuing the available coal, plant, and improvements on the basis of the returns, discounted to the present time, and the reserves on probable margins deferred forty years, the committee then advances the following estimate for the present value of the anthracite coal industry: present value of plant, improvements, and available tonnage, $843,500,000; present value of reserve tonnage, $146,400,000; total value, $989,900,000. The available recoverable tonnage is estimated at 3,908 million tons and the reserve tonnage at 5,072 million or a total of 8,980 million tons.

As previously indicated, the Coal Commission was disposed to question the method of procedure adopted by this committee and points out several inconsistencies in its estimates. The Commission found, for instance, that the actual book value of all the companies owning eighty-one per cent. of the coal and producing eighty-five per cent. of the present output amounted to only five hundred and twenty million dollars. On this basis it is inclined to fix the gross value at around six hundred million dollars or possibly six hundred and forty million after making allowance for some forty million dollars of certain memorandum accounts. The Commission interprets this discrepancy of some three hundred and fifty million dollars in the committee's estimate as representing a capitalization of monopoly profits.

The Coal Commission was unable to make any estimate of the original cost of the anthracite properties, but it did discover where extensive revaluations for tax purposes had been made during the period between 1913 and 1921. Excluding the forty million dollar memorandum account already mentioned, these upward revaluations in the case of some of the railroad companies amounted to seventy-

eight million dollars with an additional fifteen million by some of the independent companies. To this we might properly add the appreciation in value of the coal properties of the Delaware, Lackawanna, and Western Railroad when these were disposed of to the Glen Alden Coal Company; the assets of these coal properties were carried on the books of the railroad company at six and one quarter million dollars but were entered on the books of the coal company at seventy-two and one quarter million dollars. The total accretion in book value discovered by the Commission during this period thus amounted to some one hundred and sixty million dollars, again omitting the forty million dollar memorandum account previously mentioned. Adding to this some twenty-six million dollars' appreciation in book value made outside of the period 1913–1921, we have a total of one hundred and eighty-six million dollars under this head, which, deducted from the estimated current book value of six hundred million dollars as made by the Commission, gives us an original cost figure of four hundred and fourteen million dollars.

It thus appears that the approximate value of the anthracite industry, as near as we are able to estimate on the basis of actual cost, is in the neighborhood of this amount. These figures are, however, subject to two inaccuracies. While most of the revaluation above noted relates to coal land it appears to be doubtful if all the assets considered are exclusively concerned with the production and sale of coal. In a good many cases these entries can also be explained by reimbursing the capital accounts for amounts previously charged off through excessive depletion and depreciation, or of improvements charged directly to operating expenses. On the other hand, the Commission admits that there were probably other appreciations in book value which its accountants

were unable to identify. If we accept these two discrepancies as of equal weight, the net result is a return to our original estimate of four hundred and fourteen million dollars as the actual cost of the anthracite coal industry. It is rather significant to note that this figure checks fairly close with estimate of the invested capital as prepared by the U. S. Census, which is four hundred and thirty million dollars.

VALUE OF THE BITUMINOUS INDUSTRY

The problem of working out an approximate valuation of the bituminous coal industry is substantially more difficult than in the case of the anthracite. In the latter we had something of a more tangible nature to grapple with in the relatively small number of large companies controlling some eighty per cent. of the intrinsic wealth of the industry. The large corporation is also a factor in the soft-coal industry but an insignificant one in comparison with the anthracite. The bituminous industry is dominated by the class of producers that might be reckoned as from the average-large up, which in themselves are almost innumerable, but in addition to this we have an endless array of the still smaller classes, ranging from the country bank for loading wagon coal in the winter on up.

For the best information available on this subject we must again refer to the report of the special committee prepared under the direction of the U. S. Coal Commission and already discussed in the preceding section on the value of the anthracite industry. This committee based its report on the estimates of the total tonnage prepared by the U. S. Geological Survey, from which it made reductions of more than half to allow for waste in mining and thin, unworkable seams. These tonnage estimates are dis-

cussed at length on page 31 and it must be remembered that they are susceptible to serious inaccuracies.

In preparing its estimate the committee assumed a production of one billion tons of coal at the end of forty years and classified the tonnage that would be produced in this interval as available coal. The workable coal that would be remaining at the end of that time was classed as reserves, care having been taken to exclude inaccessible seams and those lying at excessive depths or being too thin to justify economic operation. It was endeavored to make the reserve coal represent as nearly as possible the tonnage that would have a tangible sale value at the end of the forty-year period.

The value of the available coal was fixed by discounting the probable future earnings so that these values automatically include the working capital, plant, development, equipment, housing accommodations, and other properties connected with the business. The value of the reserves is, of course, the value of the land only and is much less than that of a developed property.

The value of the available tonnage as worked out by the committee amounted to 6,286 million dollars and it is of the opinion that this is the minimum on which earnings should be based. It found, also, that the operators are holding considerable reserve tonnages to protect their future supplies and that sufficient allowances must be made in the earnings to take care of this extra charge. The reserve tonnage item in the committee's estimate amounted to 5,157 million dollars, making the total value of the bituminous coal industry 11,443 million dollars. The estimate of invested capital in the bituminous coal industry as prepared by the U. S. Census Bureau is 1,930 million dollars.

The committee's report cannot be construed as repre-

senting the entire value of the coal industry, since it has eliminated from consideration such important items as the 481 billion tons of lignite coal in Montana and Wyoming and 86 billion tons of sub-bituminous in New Mexico as well as some 350 billion tons in other States, or a total of more than 917 billion tons. In view of the fact that the combined total of the bituminous and lignite reserves is estimated at only 1,593 billion tons and that some of those omitted are already being worked in a limited way, it certainly appears reasonable to believe that these may be of recognizable value within the committee's forty-year period.

OWNERSHIP

A unique situation exists as regards the ownership of the anthracite coal properties which makes it necessary to review briefly some of the special conditions surrounding that industry. First it must be recalled that the anthracite deposits are confined to a very limited area in Eastern Pennsylvania, thus presenting favorable opportunities to monopolistic control. There are two or three deposits of so-called anthracite in other sections of the country, but the production from these is less than one per cent. of that from the Pennsylvania fields and their quality much inferior to the true anthracite. In fact, it can be assumed for all practical purposes that the Pennsylvania anthracites have no competitors among the known coal fields of the world, with the exception of those in Wales, the production of which has not yet been a factor in this country for economic reasons.

We have already covered in some detail the great hardships under which the initial development of the anthracite fields was inaugurated. As more mines were opened and the industry began to get into its stride, a disastrous com-

petition for business developed both between the various railroads that had built into the fields and the purely mining companies themselves. In order to obtain business for their lines the railroads soon began to embark in the mining of coal, thus beginning the accumulation of vast reserves into the hands of a relatively limited number of owners. This buying up of the lands eventually developed into a race with the different roads paying exorbitant prices in their endeavor to consolidate their own interests and keep out competitive lines.

When the smoke of battle finally cleared away we find eight large companies, more or less directly affiliated with the railroad interests, controlling seventy-four per cent. of the production and ninety per cent. of all of the anthracite reserves. The Reading Company and its affiliated interests alone produce twenty per cent. of the anthracite coal and own more than half of the coal lands. Even the remaining twenty-six per cent. of the production was rather closely held, half of this being controlled by nine independent companies, not including the largest producer in this class, which had an affiliated interest with one of the railroads. The proportion of independent coal produced has been steadily decreasing; in 1895 it amounted to forty-five per cent. of the total tonnage, as compared with twenty-four per cent. in 1921 and the production of the Susquehanna Collieries Company, amounting to six per cent., might quite properly be deducted from this as well.

The ownership of the anthracite coal industry is now largely in the hands of the following companies, the total assets of which we give as of December 31, 1922: Pennsylvania Coal Company, $16,316,864;[1] Hillside Coal and Iron Company, $3,283,875;[1] Lehigh Valley Coal Com-

[1] Memorandum accounts for depletion and depreciation purposes indicate a value of forty million dollars in addition to this.

pany, $68,245,151; Coxe Brothers and Company, Inc., $8,154,085; Philadelphia and Reading Coal and Iron Company, $115,064,815; Scranton Coal Company, $4,697,333; Lehigh and Wilkes-Barre Coal Company, $39,127,208; Lehigh Coal and Navigation Company, $77,018,864; Hudson Coal Company, $42,100,782.

Though there are 174 producing companies in the anthracite fields the fact remains that the available supplies of this kind of coal have, to all practical purposes, been cornered by a relatively small group which commands unlimited powers for good or evil. As owners they are entitled under the law to restrict development for the purpose of enhancing values as they may see fit; or in the case of the lessor they are in a position to exact whatever royalty the market may stand. It is gratifying to note that the U. S. Coal Commission particularly absolves the anthracite operators of any iniquitous practices of this kind, with possibly some very rare exceptions. But the Commission does regard the situation in general as not in keeping with the accepted standards of American institutions and feels that the public interest demands that certain regulations be established for fixing prices and scrutinizing the earnings of the companies.

While the anthracite industry is grouped in the hands of some two hundred concerns, there are more than six thousand commercial companies in the bituminous field, operating over nine thousand mines. In addition there is a very large number of consumer-owned mines, not to mention an almost innumerable array of country banks and wagon mines having no rail connections. In so far as the ownership of undeveloped land is concerned, the federal government itself is preëminently in the lead with something in the neighborhood of fifty million acres, equivalent in area to the whole of Pennsylvania and West

Virginia, with Connecticut and Delaware thrown in for good measure.

A special committee of the Bituminous Operators Association filed a memorandum with the U. S. Coal Commission during 1923 in which it was estimated that the number of investors in this branch of the coal industry probably exceeded the number of employees engaged in it. This committee placed the number of persons holding direct investments in the industry at 202,618 and estimated that there were at least 200,000 more indirectly interested through ownership of stock in holding companies. Of the 3,201 organizations examined, 2,430 were found to be operating corporations, 423 partnerships, 206 individual enterprises, and 109 subsidiary corporations. More than a third of these operations were of relatively small size, producing from ten thousand to fifty thousand tons of coal a year.

The vast majority of the investor's interests are in the shape of stock, 124,256 out of the total of 125,967 investors reported being in this class. Of the remainder, 1,505 were partnerships and 206 individual owners. These figures, of course, do not take into account a large number of banking interests engaged in financing mining projects and also the bond holders.

These figures are of interest as throwing light on the problem of nonresident ownership, which, there are many who believe, is the fundamental cause of the labor difficulties in the coal industry. That this condition does exist to a marked degree is not open to dispute, but what the solution to the problem will be is a question that has yet to be solved.

Consolidations in the bituminous industry for the purpose of restraining trade or controlling prices are notable chiefly for their absence. The U. S. Coal Commission was

strongly of the opinion that such consolidations, grouping, or pooling of the interests would create a marked improvement throughout the industry and should not only be permitted but encouraged. The Commission undoubtedly advances this opinion with reservations, for while no one would question the resulting advantages, we surely would not care to see this consolidation effected to the extent it has been in the anthracite industry without some very definite measures for protecting the public interest.

Consolidations of the operating interests would tend to centralize the management and cut down the overhead, while at the same time it would improve the general character of the supervision, particularly along technical lines. It would also result in more uniform working schedules and a greater stability in the coal markets and permit of a unification of low- and high-cost mines so that the former could carry the latter and thus assure the maximum recovery of coal.

CONSUMER-OWNED MINES

A rather surprising proportion of the bituminous production of the country emanates from mines owned or controlled by some of the larger industrial corporations, principally the iron and steel companies. The reasons for this are various, the most urgent being the necessity for obtaining an assured source of supply of a more or less special grade of coal, as is the case with the steel companies. The kinds of coal suitable for use in the manufacture of iron and steel are relatively limited and as the cost of this is the largest single item in the cost of manufacture, the steel companies obviously could not afford to be dependent on outside sources of supply which in an emergency would be in a position to exact any price they might see fit to ask.

A very detailed study of the extent and character of the consumer-owned mines was made in a series of articles appearing in the *Black Diamond*, for which we are indebted for much of the following data. According to statistics prepared in this study, which was incomplete and based partly on estimates, the consumer-owned production of bituminous coal in 1920 amounted to 24.6 per cent. of the total, including that coked in beehive ovens at the mines, the proportion of which to the total for the country was 61.9 per cent. About fifty per cent. of the consumer-owned production is from mines controlled by the steel companies, who obtain more than three fourths of their requirements from their own mines. The railroad companies are the next in importance in the consumer-owned class, producing about thirty per cent. of their requirements, or about eight per cent. of the total production of the country. The remaining twelve per cent. of the consumer-owned production is from mines owned by various kinds of industrial companies other than the steel and iron companies.

As a general rule the average steam consumer does not find it profitable to go into the mining of coal for the reason that there are very large sources of supply for this grade and the consumer is always assured of a closely competitive market in which to negotiate his purchases. The Hepburn Act limiting the activities of the railroads in the commercial markets has also tended to put a restraining influence on their incursion into the producing field. The proximity of some industries to the coal fields has been a factor in stimulating their interest in producing their own coal, examples of this type of producer-consumer being the lime, brick, and tile manufacturers.

The unprecedented high prices of coal during recent years have no doubt caused the large industrial consumers

to consider the matter of embarking in the coal business more closely than ever before, but just what the tendency is in this respect is problematical. The steel companies will undoubtedly continue in the business and may even extend their operations, but the practice may become less general in other lines with the return of more stable prices. As a rule it has been found that operating costs at the consumer-owned mine are higher than at the average commercial mine [1] for the reason that under the force of necessity as developed by the competition in the commercial markets, these latter mines usually find a means of effecting greater economies than are possible at operations not subject to pressure of this kind. Thus we find the proportion of consumer-owned mines increasing and decreasing with the rise and fall of the coal markets. In periods of a dull market these mines frequently find that they cannot compete with the commercial mines in the same field so that they sometimes sell out or close down temporarily, pending a resumption of more active business. A number of the large consumer-owned mines of the Middle West, including a large operation of the U. S. Steel Corporation, encountered this condition in 1923; as a result they covered their requirements with contracts at a figure less than they could produce the coal for and closed down their mines for an indefinite period.

The consumer-owned mines present some of the finest types of advanced practice in coal engineering that we have, a typical example being that of the Lynch mine of the U. S. Steel Corporation in West Virginia, which holds the record for the largest tonnage of coal put over a single tipple. The Standard Oil Company has also developed a shaft operation along somewhat similar lines in the

[1] The author wishes particularly to exclude from this general statement a consumer-owned operation with which he was connected for some six years.

Illinois field. These companies, of course, have unlimited resources behind them and believe that these heavy initial expenditures will be more than compensated for by the economies which they will effect. The mines in the consumer-owned class also enjoy better working schedules than those in the commercial field, the difference amounting to an average of 2.7 days per month, according to figures compiled by the U. S. Coal Commission. The economic importance of this extra working time is covered in some detail in the next chapter and in view of all these advantages it would be expected that the consumer-owned mine would be productive of better results than has been realized from it.

According to the articles we have already mentioned in the *Black Diamond* the States of Washington, Montana, and New Mexico have the largest production from the producer-owned mines, it being estimated that two thirds of the output of those States belong to that class and about half of the production in Utah. Coal mining, as a rule, has not been such a profitable venture in the more irregular Cretaceous measures of the West as it has in the more uniform Carboniferous seams in the East. Private capital has not, therefore, been attracted into the coal business to the same extent that it has in the East and the large consumers in the West have thus had to rely more on their own resources. All of the transcontinental railroad systems mine practically the whole of their supplies, as do the large metal mining and metallurgical companies as well. About forty per cent. of the production in Colorado and Wyoming is from consumer-owned mines, forty-six per cent. in Alabama, thirty-one per cent. in Pennsylvania, and twenty-seven per cent. in Illinois.

If one may venture a prediction it appears from the present outlook that the proportion of steam tonnage

originating at the consumer-owned mines will probably decrease in the future, assuming, of course, that the market conditions are fairly stable. The railroads will very likely continue about as they are and the same is true of the iron and steel industry, though the latter would be more likely to show an increase. Public utility concerns are showing a decided leaning towards producing their own fuel supplies and are the one branch of producers in which there appears to be a marked tendency in this direction.

SIZE OF OPERATIONS

The unification of the anthracite industry into large units has already been covered at some length. The salient characteristic of the bituminous industry is rather the reverse and we shall now endeavor to analyze the variation in sizes, with the proportions in the different groups and their tendency to increase or decrease, together with the influence of the size of the mine on the cost of production, for practically all of which data we are indebted to a very exhaustive investigation of this subject by the U. S. Coal Commission.

The accepted measure of the size of a mine is the annual production. This is misleading in some respects since no recognition is taken of the acreage included within the proposed limits of the mine or of the extent of the improvements, though this last must necessarily conform approximately with the mine capacity. It is, however, the most convenient method of making comparative analyses and is sufficiently representative of the size of the operation to suffice for this purpose.

In point of both numbers of mines and numbers of producers, the wagon mines shipping by rail (excluding local commercial mines) are far in the lead with a total of 4,405

each. This represents thirty-six per cent. of all the producing companies and thirty per cent. of the mines, though the production originating from this source is only 0.79 per cent. of the total, indicating the insignificant character of this business as compared with the whole. The next largest number of producers and mines is in the class with an annual production of between ten and fifty thousand tons a year, which numbers 2,121 producers operating 2,381 mines, both of which figures are more than twice that of any of the other classes. There are over fifty-three million tons a year produced by these mines, or 9.38 per cent. of the total output. The class producing the greatest tonnage is the operator with an output of between one hundred and two hundred thousand tons a year, more than seventy-five million tons of coal originating from these mines, or 13.28 per cent. of the output for the country.

Beginning at the ten to fifty thousand ton class of producers, of which it will be recalled there are 2,121, there is an abrupt falling off to 727 in the next higher class producing from fifty to a hundred thousand tons per annum. The decline in the number of producers continues persistently with the increased rate of production culminating at twelve in the class with eight hundred to nine hundred thousand tons' capacity, and varying erratically between seven and seventeen in the remaining classes up to those with three million tons' capacity. In the class with three to five million tons' output there are again twelve producers and in the last class, companies having a production greater than five million tons per annum, there are four.

If we plot a curve showing the proportion of tonnage produced by the various classes it will be found to conform to certain definite laws with striking uniformity. Begin-

ning at practically nothing with the country bank it shows a steady increase culminating at 13.28 per cent. with producers having an output of between one hundred and two hundred thousand tons per annum. An equally persistent decline from this maximum level then occurs, terminating at 1.78 per cent. with the producers having a production of eight hundred to nine hundred thousand tons, followed by another upward swing to 7.72 for operators with a production of three to five million tons and 7.12 per cent. for those in excess of this.

There does not appear to be any marked trend either towards or away from the large producing unit in the bituminous industry, increases in one direction being generally balanced by decreases in others. During the period 1905 to 1920, the percentage of the whole production originating from operators with an output of one hundred thousand tons per annum showed a uniform increase in the later years. In the one hundred to five hundred thousand ton class there was a decrease from 33.4 per cent. in 1905 to 31.8 per cent. in 1920, the two succeeding classes, covering the range from five hundred thousand tons up to five million tons, showing first an increase and later a decrease.

The size of the operation is of economic importance because of the very great difference in efficiency in favor of the large capacity mine. This difference has long been recognized in the coal industry and is one of the reasons for the Coal Commission recommending that the consolidation of the large units be encouraged. In 1921 the production per employee at mines with an output of less than ten thousand tons per annum was 2.70 tons; in the ten to fifty thousand ton class the production was 3.45 and at mines with an output of two hundred thousand tons or more the production per employee was 4.73 tons.

EARNINGS OF THE COAL COMPANIES

Some reference to the earnings of the coal companies has already been made in the section devoted to the cost of the coal to the consumer, but this subject is of too great importance to be passed over in an incidental manner and we will, therefore, take it up. The discussion is here limited to the operating or the combined operating and sales companies, eliminating the wholesaling and brokerage companies, the earnings of which have already been covered in some detail.

The earnings of the anthracite companies have been the subject of the greatest interest because of the general belief that these companies have been largely responsible for the rapid increase in the cost of this grade of coal. An examination of the profits of the leading hard-coal companies over the past decade as disclosed by the U. S. Coal Commission certainly tends to substantiate this belief. The net income of the railroad companies, excluding the Glen Alden Coal Company and before deducting federal taxes, had, previous to 1917, ranged between eleven and sixteen million dollars per annum. In that year, however, they took a sudden jump to thirty million and have been ranging between twenty-two and thirty-three million since, with the exception of the strike year, 1922, the general tendency being upward.

A still more significant factor in this connection is the increase in the accumulated surpluses of these companies that were actually earned — that is, exclusive of the revaluations of the assets. The surplus of the Lehigh Coal and Navigation Company increased from a million and a half in 1912 to eight million in 1921, and that of the Philadelphia and Reading Coal and Iron Company, which started with about the same amount as the Navigation

Company in 1912, had increased to twenty-nine million in 1922. A portion of the Navigation Company's increase was derived from transportation income and the Reading Company paid no interest on some very considerable advances from its parent company, but the increases are still enormous, even after making generous allowances for these items. The combined earned surpluses of six of the dividend-paying railroad companies engaged exclusively in the mining and selling of coal increased from nine and one half million dollars in 1912 to fifty-three million in 1919. These surpluses were reduced thirty-seven million dollars in 1921, chiefly by the payment of large extra dividends,[1] and declined again in 1922 to twenty-seven million dollars, presumably due to the strike. These figures do not include the results of the Glen Alden Coal Company, which is admittedly one of the most profitable of the large anthracite companies, owing to its low costs of production. For instance, the margin between the cost and selling price for this company during the first quarter of 1923 was $1.48 as compared with an average for the other railroad companies of ninety-three cents.

In the bituminous field it would obviously be impossible to attempt any comprehensive survey of the earnings for the whole industry or even any specific classes of producers and we shall confine our discussion of this part to an examination of the results of one of the larger companies. The Consolidation Coal Company being one of the largest producers of bituminous coal in the country, if not in the world, may be taken as representative for the industry. This company is not only a large producer but has a very

[1] The Lehigh Valley paid a dividend of 134 per cent. out of its surplus in 1920, the Lehigh and Wilkes-Barre one of 227 per cent., the Hillside Company one of 205 per cent., and the Pennsylvania Coal Company nearly seven million dollars, all of these last in 1921.

elaborate and progressive sales organization and handling equipment, including large dock facilities on the seaboard and the Great Lakes.

The annual report of this company for the year 1922 showed gross earnings from operations of $22\frac{1}{2}$ million dollars. Operating expenses, insurance, royalties, taxes (except the federal tax), depreciation, and depletion amounted to $19\frac{1}{3}$ million dollars, leaving the net earnings from operations for the year slightly better than three million dollars. Adding to this the income from other sources and deducting interest and the income tax, the net income, after all expenses, is $2\frac{3}{4}$ million dollars. The company produced nearly $5\frac{3}{4}$ million short tons so that the cost per ton before deducting the tax and interest was around $3.40 and the sales realization about $4. The profits per ton after deducting all expenses would, on this same basis, be about forty-five cents.

Judging the earnings of the coal companies by the tax returns to the federal government, however, the results for the industry are very discouraging. These returns for 1921 show that twenty-six hundred corporations, out of a total of thirty-six hundred, had no net returns at all, showing instead deficits aggregating more than seventy-two million dollars. However, it is gratifying to note that the remaining one thousand corporations recorded earnings sufficient to make up for these deficits and leave a balance to the good of ten million dollars. The tax on the profits of these latter companies, which amounted to better than eighty-two million dollars, was slightly over fifteen million dollars, of which seven million was for income tax and eight million war profits or excess profits tax.

CHAPTER III

Economic Problems

COMPETITION AND OVERDEVELOPMENT

One of the fundamental and most important economic difficulties with the bituminous coal industry is the large surplus capacity of the mines, exceeding the consumptive requirements by about one half. The U. S. Coal Commission estimated the productive capacity of the bituminous coal industry at well above eight hundred million tons per annum, whereas our max mum consumption has never exceeded 579 million tons and was only 545 million in 1923. This would indicate an overdevelopment of around fifty per cent. and this is probably approximately correct or as near as it is possible to estimate. At first glance this might appear a desirable condition, since it would tend to stimulate a healthy competition that would assure to the consumer minimum prices at all times, but a closer examination will show that it only results in an excessive economic burden, which must inevitably react on the price of the coal to the consumer.

We have already commented on the fact that the production costs at a mine working only three days a week will be twenty-five per cent. higher than when operating full time, the reason for this being the abnormal overhead charges that continue irrespective of whether the mine works or not. It should be remembered in this connection that mining cannot be compared with the ordinary

manufacturing enterprise. A business of this latter kind can be closed down temporarily without sustaining any other loss than the salaries of the monthly officials, watchman, possibly a fireman or two, and the interest on the investment. But in the case of a coal mine we have, in addition to these costs, a number of other items involving substantially larger amounts.

The first, and usually most important of these, is the matter of timbering. A mine of any consequence at all will have several miles of airways, haulways, and other standing work where it is essential that the roof be maintained, and in the case of some of the larger and older mines this may amount to from fifty to one hundred miles or even more. The amount of labor and material required for this will vary with the roof conditions, but under even the best conditions the operator cannot expect to be free from any expense along this line, and where the mine has a notably poor roof it may involve keeping one or more crews of men continuously on this.

Drainage is also a very important part of the overhead at some mines, though this is less general than in the case of timbering and may be comparatively nothing in some instances. It is not unusual, however, for an average size mine to be pumping anything up to five hundred gallons of water per minute through a considerable head, and where this condition exists, it means more or less continuous operation of the power plant, though not necessarily at full capacity, employment of the pump attendants, etc. Where men are working in the mine the ventilation will have to be maintained, in part at least, and power provided for the hoisting and haulage equipment and to operate other machinery on the surface. It will thus be readily seen that an enormous waste results directly from this condition of overdevelopment, — a loss that must in

one way or another be eventually passed on to the consumer.

There are also additional losses from this cause of a more indirect nature and more difficult to measure in dollars and cents but possibly of even greater economic significance. As will be shown farther on the relatively short working time of the mines has made it necessary to establish an abnormally high wage scale on a per diem basis, in order that the miners' earnings for the year will compare favorably with those in other industries. The existing wage scales at the coal mines to-day are admittedly out of line with those in other industries requiring equally skilled workers, though the miners' earnings for the year will be less. If we may accept the Coal Commission's estimate that the industry is overmanned to the extent of twenty thousand employees and assume the average rate of these at $6.50 per day, we get some conception of the magnitude of the economic loss from this cause.

The extent of the overdevelopment is well indicated by a review of the working time at the mines which, in the past quarter of a century or more, has averaged only 213 days per annum out of a possible number of 308, excluding Sundays and legal holidays. Coming down to present-day schedules the situation appears even less favorable, the working time in an active year like 1920 amounting to only 220 days while during the following year, which was one of depression, the mines averaged only 149 days. Some of this time was lost through car shortages and strikes, though the total of these amounts to a surprisingly small percentage of the whole, and was made up by increased production at other times, as must be self-evident since the country has always been supplied with coal.

Another interesting analysis of the extent of this overdevelopment was compiled by the Coal Commission.

During the period from 1918 to 1921 the number of mine workers increased from 615,000 to 663,000, while the production declined from 579 million tons to 416 million. This was not due, as it might first appear, to a reduction in the daily output per miner, since this has increased from 3.5 tons in 1910 to 4.2 tons in 1921. The cause is attributed instead entirely to the decrease in the number of days of work.

The causes of the overdevelopment are of various kinds, the present condition being in a large measure due to the large profits resulting from the generally high prices during and since the war. The railroads naturally encourage the opening of new mines since this means increased revenue for them, and a number of large consumers have been actively developing their own coal properties in recent years to protect themselves against a recurrence of the recent high prices. There are besides this other contributing factors, such as changes in the centers of consumption, unionization of certain fields, etc.

Bearing these conditions as to overdevelopment in mind the reader will be able to grasp some of the fundamental principles underlying the condition of ruthless competition that has been a further cause of great economic loss to the industry. The competitive spirit has been recognized as a dominant characteristic of American industry but in no other lines have there been the incentives back of it that there are in the coal industry. When the average operator contemplates the daily loss from an idle mine running into a hundred dollars or more he is liable to cut prices down to a profitless basis, not infrequently disregarding such refinements as depreciation and depletion, in his endeavors to keep the mine going.

The abnormal demand occasioned by the great industrial expansion during and succeeding the war period has

greatly diminished the extent of this competition though it is gradually becoming more evident again. Previous to the war, competition raged so aggressively in the bituminous industry that the profitable company was the exception rather than the rule. Some of the largest concerns had passed from one receivership into another; coal securities were a drug in the financial markets, and a good many banks were auditing and paying the accounts for insolvent operators. It was a dark era in the coal industry with a future of uncertainties.

Competition of almost every conceivable kind exists in the industry. In its broader aspects we might first consider the competition between anthracite and bituminous coal. This is confined largely to the steam sizes of the anthracite coals, though with the increasing shortage of the domestic grades the consumer is being forced to a more general consideration of bituminous substitutes for these as well. Competition within the anthracite industry itself is more or less limited, due to inadequate supplies of this grade and the method of fixing standard prices as adopted by the operators producing the bulk of this coal. There is a limited competition between producers of different qualities of anthracite and between the independent companies in times of an active market.

In the bituminous industry we have first the broad general competition between the large fields such as the Pennsylvania, West Virginia, Kentucky, Ohio, and Middle West. All of these fields have certain limited territory of their own but there are points of contact between where the business is highly competitive. Next there are the competitive interests between the different districts within these fields, such as the smokeless and high volatile fields of West Virginia, the eastern and southern fields in Ohio, and so on. The operators in these respective districts are

commonly organized into some kind of association for the common protection of their mutual interests in the matter of freight tariffs, unreasonable taxes, negotiating wage scales, etc. And finally we have the competition of the individual operator with his contemporaries in the immediate vicinity of his own mines. Thus it will be seen that there is a very general and wide distribution of competition throughout the bituminous industry.

The extent of the competition between the different fields can sometimes be measured in terms of their relative increases in productivity, the Honnold Coal Bureau in Chicago having drawn an interesting comparison along this line as regards the Illinois field and its chief competitors. This comparison shows that while the production of the State of Illinois has increased 850 per cent. since 1880, that of its chief competitors has grown much more rapidly, the increases among these during this same time being: Indiana, 950; Kentucky, 4,150; West Virginia, 4,300. Thus while the Illinois and Indiana mines have made a very remarkable record it is apparent that they have not been holding their own in competition with some of their rivals.

Besides the competition within the industry itself, coal has had a rather formidable rival in fuel oil in the past half dozen years as well. A survey of the situation in New York at the close of 1923 showed that some 200,000 tons of anthracite were being displaced by fuel oil annually, and the situation in the New England cities is no doubt more accentuated. That the anthracite operators are concerned over this competition of the oil burner is evidenced by the counter publicity campaign they have initiated. Fuel oil has also found a wide application for use in industrial and manufacturing plants and has been an important factor with the railroads in the West and South-

west for a good many years. From the best information available, however, it appears likely that the competition from this source will be of a more or less temporary nature, since all of the more important oil fields have apparently been discovered and are either at their maximum production or on the decline.

Natural gas has also been a local competitor with coal in sections where it has been found, but this also is on the decline, with a great many of the companies engaged in this business hard pressed to furnish adequate supplies when the temperatures are low. At the present time the coal industry does not suffer any serious competition from outside agencies in its own field.

COÖRDINATED METHODS ABROAD

For a survey of the early methods of coal mining, described in the first part of the book, we found it necessary to fall back on the history of the industry abroad. The European operators have been steadily ahead of those in this country, due to the advanced stage of the industry there. Since the beginning of coal history they have grappled with the great problems that have arisen, before we have hardly begun to anticipate them. These problems have been solved, for better or worse, and it behooves us to learn what we may from these solutions, in so far as they are comparable with our own conditions.

Of the economic problems in the European coal industry to-day, the question of labor stands preëminently at the front, particularly in England. Casting back over the labor history of the country, one is first impressed with the vast and revolutionary aspects of the changes in the condition of the mine worker. To-day the coal owners are appearing before delegations of the workers to explain just what they mean by such theories as "the inherent

rights of ownership as opposed to the common good" — a far cry indeed from the conditions of a few centuries ago when the government designated certain commissioners "to seize workmen and coal bearers wherever they could be found, with full power to imprison and punish them" (p. 41). The transition in the status of the worker has progressed by successive steps from slave to wage earner, hence to profit-sharing, and he is now endeavoring to achieve a partnership in the mines by nationalizing the industry, a result which he shows very good prospects of accomplishing.

The existing conditions as regard labor in England are of pertinent interest if they are to be regarded as presaging developments in this country. Here again we find the British industry advanced (if advance it may be termed) well ahead of us in that the miners have achieved to a position of control unparalleled in the history of labor. As a result of this condition they have been able to virtually reconstruct the economic system of the coal industry along the most revolutionary lines, and the methods by which this has been worked out are of more than ordinary interest.

After an interminable series of negotiations the miners' demand for a more definite recognition of labor's share in the industry was met with a sliding-scale agreement in which wages were based on the selling price of the coal. This in itself was not an unusual arrangement, having already been practiced in a measure by some of the larger metal mining companies in this country for a number of years, but the results as applied to the British coal industry were not satisfactory. Under this method there was no inducement offered the miner for exerting his maximum effort towards reducing costs and increasing the production; on the contrary increased costs and restricted pro-

duction tended towards higher selling prices, and consequently higher wages, so that the industry was threatened with economic disaster under this system.

The idea was then conceived of basing the wages on a percentage of the profits accruing to the operators. This method has met with the approval of the majority of the best informed on both sides of the question but is not without its critics and has introduced a number of puzzling inconsistencies that are exceedingly difficult to adjust. Under the terms of this agreement the miners' wages, in cases where profits are meager, are given certain precedents over any return to the operator, a provision which the latter condemns as unfair. Difficulty has also been experienced in arriving at an exact basis for computing just what the profit is, much the same as has already been noted in the case of the anthracite companies in this country. Certain items properly chargeable to costs have been definitely ruled out, such as interest on capital and loans; amortization charges; income and corporation profits taxes; contributions to trade associations, etc. The plan also works unfairly to miners employed at the high-cost operations, and the workers complain that the companies sometimes sell at unreasonably low prices with a view to recouping a loss thus sustained through some affiliated interest, the profit in which does not accrue to the miner.

From an operating standpoint the plan has everything to recommend it as it tends to promote the maximum cooperation between the employer and employee and throws a very definite responsibility on the latter in the matter of reducing costs. Observations indicate that the miners are fully cognizant of this responsibility, an inherently careless or wasteful workman being subjected to severe criticism, or worse, by his fellow miners, and very unusual

efforts at effecting economies being made by the workers in many directions. It is difficult to forecast what the future holds for Great Britain in these revolutionary times, but the student of economics cannot but be impressed with the potentialities of an industry wherein the interests of the employer and employee have been made so interdependent on each other.

We have already commented upon the absence of coal exchanges in this country (p. 187) and in this respect we find the British industry well equipped. Practically all of the coal is traded in at the exchanges, little or no business being done by personal solicitation as in this country. The entire coal trade, including those engaged in transportation, keep in daily touch with the exchanges and any one interested in any particular phase of the market can secure the required data quickly and accurately at this fountainhead of information.

More systematic operation of the transportation systems, together with the comparatively short hauls, has made our problem of car shortages an unknown factor in the British coal industry. This, together with the fact that it is the uniform practice among the consumers to keep liberal reserve stocks available for emergencies, has tended to stabilize the trade and eliminate the possibility of the constantly recurring shortages and panicky markets that are characteristic phenomena of the trade here. There are many things which the American coal operator might learn to his advantage from the British methods as well as some points of interest for the consumer and railroad companies, but it must be remembered that there is a wide difference in natural conditions that would not make these methods easily applicable in every instance.

Germany, too, has achieved certain results in coal economics that are well worth considering; in fact conditions

in the German coal industry are, or were, closely parallel to certain recommendations made by the U. S. Coal Commission for correcting some of the major difficulties under which the bituminous coal industry in this country is laboring to-day.

The conditions of extravagant competition and duplication of selling effort with which we are now having so much trouble were also characteristic of the German coal trade at one time and led the operators in the Ruhr district into forming an association for the purpose of eliminating this evil. The association was known as the Ruhr Coal Syndicate and was designed purely for selling and marketing purposes. All the participating companies were allotted a certain annual tonnage, which was adjusted from time to time, and the Syndicate took the full responsibility of marketing the coal thus accumulated, at prices fixed at the general meetings of the Syndicate. The Prussian state mines were themselves members of the Syndicate, with an allotment of ten per cent. of the total tonnage, which latter aggregated about two thirds of the entire production of Germany.

The weak point in this method as applied to our conditions would be the violation of our anti-trust laws in the matter of fixing prices. It is apparent that there would have to be a radical readjustment along this line, which might be accomplished by means of strict government regulation, before the method could be tried. But it is equally apparent that it would effect incalculable savings in the public coal bill and is, therefore, well worth an exhaustive study.

CONSERVATION

In the chapter devoted to Our Coal Reserves, we have discussed in considerable detail the best available

information on the coal resources of this country, the rate of exhaustion, and the probable life of these reserves, and have made a comparison of the situation in this country with the other chief coal-producing countries of the world. We have shown that the data, both as to resources and rate of depletion, are of an exceedingly vague character, so much so, in fact, that they give the conservationist a rather flimsy structure on which to build his case. We have even gone so far as to suggest a possible solution for the Fuelless Age, based on the prospective advances in science.

But while we can look down through some centuries to come with complacency as regards our fuel supplies this does not in any way relieve us of responsibility to the future generations. Whatever other unknown factors there may be in the equation we are facing two positive conditions about which there can be no dispute. The first is a large supply of an essential commodity that cannot be replaced; the second is a relatively minute but increasing consumption of this commodity. Given these conditions supplemented by an unlimited time period and we must accept it as axiomatic that a crisis will be reached sometime.

Conservation is a matter that has engaged the serious attention of some of the leading men in the coal industry and has no doubt been the subject of thought for economists in all lines. A review of past methods in coal mining indicates beyond doubt that there have been enormous losses in the mining of coal — losses that can never be recouped — and it is in this direction that the coal industry must exercise its ingenuity in the interests of conservation. With the U. S. Coal Commission estimating that more than one third of the bituminous coal is lost in mining operations, there is still ample room for improvement along this line.

The operator, on the other hand, must not be accused of willful extravagance in this respect. It must be remembered that he is facing a contest for economic existence as against other operating interests and that he cannot be expected to assume a financial burden in the public interest that might very easily drive him into bankruptcy. The self-interest of the operator, however, demands a very careful consideration of this matter and it is on the increasing importance of this that we must rely for our main effort in realizing the most there is to be had from our coal seams. Within certain limitations, it is to the operator's advantage to recover every possible ton of coal that the seams can be made to yield and thus reduce the depletion charges. With the gradual exhaustion of the coal lands, and the resulting increase in value of those remaining, this is a matter that will come in for more consideration; in fact there is a very marked tendency in this direction already, as is evidenced by the mining methods of some of the larger and more progressive companies.

The principal loss in mining coal is in the pillars which are left in to support the roof during the mining operations, as explained in the part on Mining Methods. The extent of these losses is governed first by the roof conditions and second by the intelligence with which the system of mining has been worked out to meet the particular requirements of the individual mines and the degree of supervision exercised in enforcing adherence to this system. The maximum losses occur where the roof conditions are the most unfavorable and no method of mining has been devised that will entirely correct this difficulty. New systems of mining are being evolved almost every year, the main object of which has been to effect a greater recovery of the coal and each decade of the last half century has seen very marked improvements in this respect. There

is no reason for believing that we have attained to perfection in our methods of working as yet, so there is much to be expected for the future along this line.

Poor or indifferent engineering is responsible for heavy losses of coal; in no other constructive line is it so absolutely essential to have the best engineering advice and service there is to be had. A very considerable part of the coal seam is sometimes left unmined for various technical reasons and there are extensive losses from this cause. Faults and a thinning of the coal over considerable areas are another prolific cause for losses in mining because of the excessive cost of working such areas. In the preparation of coal there are frequently large amounts of undesirable sizes or inferior grades wasted.

The most striking example of waste from this latter cause occurred in the early days of the anthracite industry. We have already described how the smaller sizes of anthracite coal were separated and left in the mine (p. 137) in the early days of the industry. Thus for many years after anthracite came into active use (about 1808 to 1867) everything below the size of our present chestnut coal was wasted. About the middle of the nineteenth century the market demands for the domestic sizes necessitated the introduction of crushing machinery for breaking the coal to the required size and in this process from fifteen to twenty per cent. of coal was reduced to unmarketable sizes and had to be discarded, thus starting the enormous culm piles that accumulated throughout the anthracite regions in the succeeding years. These piles contain around fifteen per cent. refuse matter, the balance being pure coal.

It was not until about 1867 that methods were devised for burning the sizes below chestnut, thus bringing these inferior grades into commercial prominence; pea coal

made its appearance about that time, and buckwheat ten years later. During the closing years of the nineteenth century these two grades were gradually recovered from the culm piles and it is a significant fact that all of these waste piles, containing these large percentages of pure coal, have since been worked over. In the meantime other piles containing considerable pure coal due to imperfections in the old breakers, had been found workable and this business is to-day an important part of the anthracite trade.

The U. S. Coal Commission is authority for the statement that the anthracite operators are now recovering an average of sixty-one per cent. of the coal in their operations as compared with fifty per cent. at the time the Roosevelt Commission made its study of conditions in the anthracite fields and twenty-seven to forty per cent. forty years previous to that. This is a highly commendable improvement, though not to the extent that one would like to see, and one which will certainly not meet with the approval of the succeeding generations when the stores of anthracite have been exhausted. The anthracite reserves have now attained to such value that rather more than ordinary measures for conserving them have become justifiable, which will no doubt result in still greater recoveries. One of the most promising of these methods is the silting process, by which the refuse from the breaker is run back into the old workings, where it solidifies and thus forms a support for the roof, enabling the withdrawal of the surrounding pillars.

The Commission made a detailed study of the prospective life of thirty-two of the larger anthracite companies, based on the current (1923) rate of production and found one company that would be producing 480 years hence and another 260 years. There were six companies with

a prospective life of from ninety-eight to one hundred and twenty-three years, eight from forty-eight to seventy years, seven from twenty-seven to thirty-nine years, eight from seven to twenty-one years, and one just mined out. The largest reserve is in the hands of the Philadelphia and Reading Coal and Iron Company, amounting to eighty-five thousand acres of coal land, the estimated life of which is considerably more than two hundred years.

The Commission also prepared some interesting figures on the actual waste in bituminous mining, on a tonnage basis, that presents a vivid picture of what this amounts to. Taking the production of 368 million tons in 1921 as the basis, it is estimated that 564 million tons of our potential reserves were exhausted in producing this; in other words there was a waste of 196 million tons in this year alone. The most impressive part of the Commission's findings, however, is that 110 million tons of this wastage was avoidable. It is not clear whether it is meant that this was avoidable in an economic sense, as already discussed here, but if so this is one of the strongest indictments that has yet been made against the bituminous coal industry; if not, it hardly seems reasonable to place the loss in the class of those that can be avoided.

The percentages of the total losses in the different States are estimated from twenty in the State of Virginia to as high as forty-nine in Illinois, an exceedingly bad record for this latter, particularly since it is the third largest producer in the country; Pennsylvania, with her production of 116 million tons, has a loss of 28.6 per cent., and West Virginia's loss in producing 73 million tons is estimated at 22.8 per cent. The avoidable loss in Virginia is estimated at five per cent., being less than half that of her nearest competitor, West Virginia, where it is estimated at 10.5

per cent. Illinois has the greatest avoidable loss, amounting to 29.7 per cent. with Indiana (26.7 per cent.) and Ohio (26 per cent.) next in order.

ROYALTIES AND TAXES

The royalty basis of working coal lands has attained a prominence that justifies some consideration of this method. Under this plan the operator leases the land from the owner, paying a certain amount per ton as the coal is extracted. The rate per ton is usually fixed at a definite amount, but in recent times there has been a tendency to adopt a sliding-scale basis determined by the selling price of the coal, and thus keep it in consonance with the fluctuating value of money. A decade or two ago royalty prices ranged from a minimum of around two or three cents per ton up to a maximum of twenty-five cents to thirty cents with six cents as a generally accepted average; to-day there is probably little or no coal to be had at less than six cents per ton and the price is sometimes as high as a dollar and a half or better.

The leasing system presents certain inherent advantages to both the lessor and lessee. In the case of the former, he realizes a substantially better price for his property, providing the conditions of the lease require a reasonably prompt removal of the coal on the part of the lessee. As an example we may assume a coal property valued at around $200 per acre; if this property were leased on a royalty basis it would probably bring twelve cents per ton and an average seam would yield six thousand tons to the acre, so that the ultimate realization to the lessor would be $720, assuming the customary risks of mining, faults, squeezes, etc., do not result in any losses. The lessee, of course, is relieved of anxiety from these latter causes other than as they may affect the mining opera-

tions and he is also freed from the necessity of making a heavy initial investment for land just at a time when funds would be urgently needed for plant and equipment.

The leasing system is general throughout all parts of the country and has recently been adopted as the method for disposing of the public coal lands in the West. It has, however, reached its maximum development in the anthracite regions, where approximately a third of the coal is now being produced from leased land. One of the largest and most interesting of these anthracite lessors is the Girard Estate, founded by Stephen Girard in the interest of a Philadelphia charity. The estate includes a little over four thousand acres of coal lands and the royalties derived from it in 1918 amounted to nearly two and a half million dollars or a little better than six hundred dollars per acre of land held. For a decade and a half previous to 1914, the royalties averaged only thirty-one cents per ton, but new leases were negotiated in that year which brought the return up to fifty-two cents, and in 1921 it had increased to $1.27 on a production of 2,983,723 tons of coal. Other leases are bringing equally high, and in some cases higher, returns to the lessors, one case being reported to the U. S. Coal Commission where an operator had paid an average of $1.50 per ton, while some leases on stripping operations are bringing still higher figures. These high-return leases are of course based on a sliding-scale price and it is interesting to note that there are some old flat-rate leases still operative at prices as low as twelve cents per ton, though most bring large revenues.

The effect of these high-cost sliding-scale leases on the price of coal to the consumer can be readily understood. A vicious circle is created wherein the increased royalty charge is passed on to the cost to the consumer, which thus automatically increases the royalty still further and

so on. The railroad companies, who are operating largely on their own lands and are thus free from exorbitant charges of this description, are able to write off excessive depletion charges against their properties. The system in general has been a potent influence in increasing the cost of coal to the consumer and should be subjected to some form of regulation.

The bituminous industry has no parallel in the leasing system with that existing in the anthracite fields, with the possible exception of the Pocahontas district. Practically the whole of this field is controlled by two large holding companies, the Pocahontas Coal and Coke Company and the Crozer Land Association. The former controlled some 275,000 acres of the Pocahontas coal field in 1913 and had some forty-five leases in operation involving 145,000 acres of its holdings. This company maintains the strictest kind of supervision over the methods of its lessees, to insure the maximum recovery of coal from its lands. In pursuance of this plan it maintains a well-organized engineering force, draws up the plans for development and follows up the work in the mines to see that the plans are adhered to. This is a custom that is quite generally followed by all of the larger leasing companies.

Coal companies, like all large and apparently profitable corporations, have been a favorite target for excessive taxation, by the local governments in particular. One of the most spectacular of these raids was one attempted in Schuylkill and Northumberland counties in the anthracite regions of Pennsylvania. The commissioners in the former county attempted to increase the valuation in 1922 from fifty-six million dollars to four hundred and twenty-two million and those in the latter county endeavored to effect a similar increase from twenty-four million to fifty million dollars. Where land values had been established

by comparatively recent sales at $480 per acre, an attempt was made to increase this to as much as $4,700. Pennsylvania already has an unenviable reputation as the result of a sales tax she imposed on all the anthracite coal produced within the State by which a burden of some seven million dollars a year was added to the cost of the coal.

The U. S. Coal Commission has suggested a new method for levying taxes on anthracite coal by means of a graded rate on royalties and differential profits, which appears to have considerable merit. This tax would fall most heavily on the high-profit mines and provide an incentive to continued operation of the low-profit mines in much the same way as the Federal taxes do at the present time. The range of these Federal taxes during the period from 1917 to 1921, for instance, was found to be from two cents a ton on the non-dividend-paying company to as much as twenty-eight cents on one of the most profitable companies. The Commission does not advance this as a means of lowering prices, but simply as a more equable method of obtaining revenue.

CHAPTER IV

Company Organization

The methods of organization among the coal companies vary chiefly with the size of the unit. As these sizes range from the country bank with its production of a few hundred tons a year up to the large corporation outputting ten million tons or more, there is necessarily an equally wide range in the kinds of organizations built up to meet the varying requirements of these different sized units. Other factors also have a bearing on the kind of organization adopted, such as the personal equation of those who dominate the executive board of the company. This executive board or head determines the general characteristics of the company, as recognized in the mining fraternity, and it may be progressive or conservative, altruistic or otherwise, etc.

Some companies favor one department and some another, again depending on the attitude of the executives. Where the chief executive head has come up through the sales department he will be prone to subordinate the interests of the operating department to that of the sales, and vice versa. The more progressive companies demand the best engineering talent there is available, promote advanced safety measures, and endeavor to improve the sociological conditions in their camps; others are more concerned with the matter of profits and tend to overlook these features. Again the financial condition of the company has an important influence on its general policy;

some companies struggling along under adverse mining and marketing conditions are obviously unable to adopt the more enlightened methods of those more favorably situated in this respect.

Sometimes the company is a closely held family organization in which the owners are in active charge of the management; this type of organization usually tends to greater coöperation and loyalty to the common cause in the executive personnel. More often the company is organized and controlled by a number of seasoned and experienced coal men and financed by some banking institution specializing in coal securities. Consumer-owned mines have come into considerable prominence in recent years and the policy of these companies is dictated largely by the parent company, though this rests on the degree of responsibility accorded the local management.

GENERAL PLAN

The general plan of organization rests primarily on the size of the operation. In the small country bank all of the official positions from foreman to president will be consolidated in the hands of the owner or lessee, who may also be the driver and even try his hand at surveying in an emergency. The same type of organization would apply to the small mine with rail connections, while those in the next larger scale would have a working foreman in charge with a non-resident manager, secretary, or president who would attend to the sales and buying, and who would make occasional visits to the mine to pay the men and inspect conditions in general. As these mines increased in size and importance there would be first a non-working foreman, then a superintendent and inside foreman. The inside foreman would later have one or two fire bosses, who would also be his assistants, and an outside foreman or

top boss would be added, together with a weigh boss in charge of the tipple. The organization would thus gradually expand to include all of the more intricate personnel that goes to make up the operating department of the modern large mine.

In studying the organization plan of an average large-sized company we must first consider the executive head. In the case of a corporation this will be the board of directors, which defines roughly the general policies of the company, leaving the details of execution to the chairman of the board, the president, or the general manager, as the case may be. In some of the larger companies there may be several vice-presidents in charge of different departments such as sales, operating, etc., and each of these may be responsible to the board of directors, but this is the exception rather than the rule. The general policy is to have a single executive head who alone is responsible to the board, though the various department heads may be called into conference with it.

The president or executive head has usually arrived at this position through either the sales or operating department, though sometimes he may have come up through the accounting or legal department. Occasionally the financial interests backing the company reserve the privilege of designating a titular president with an executive vice-president or general manager under him. Under this executive head, whoever it may be, we will then have two or more department heads in charge of sales and operations respectively. Sometimes other departments may be made directly responsible to the president, such as the engineering department, though it is more commonly made a part of the operating department except in the case of a consulting engineer, who would be responsible directly to the president or board of directors.

The functions of the sales department have already been discussed in some detail in the section on the Distribution of Coal. The importance of this department to the financial success of the company needs no comment. It is usually headed by a man who has come up through the sales department and is thoroughly familiar with the company's coal, customers, methods of doing business, etc., and who has as well a very broad general knowledge of trade conditions, freight tariffs and other matters pertinent to his calling. On him rests the burden of building up and maintaining the company's prestige in the business world, seeing that the mines have all of the orders possible during the dull periods and keeping disgruntled customers satisfied in times of a short market.

OPERATING DEPARTMENT

The vice-president or general manager in charge of operations will usually be a man with a broad experience in this end of the industry and he must be a capable executive with a capacity for getting results in the face of a good many difficulties. The men for this position sometimes come up from the ranks, after graduating through the successive minor positions, some of them originating in the engineering department. The duties of this position are varied, according to the size of the company. In a very large company, the executive head of the operations department will have division managers or superintendents reporting to him and thus will not come in close contact with the minor activities.

He is in charge of the purchases of supplies, for which there will be a purchasing department, directs the major activities of the engineering department, and is the court of final appeal in any disputes between the department heads. The adjustment of wage scales is left largely to

his discretion, subject to the approval of the president or board of directors, and he is held directly responsible for any increases in the cost of production and for maintaining the physical condition of the property up to the desired standard. He is also the final responsible authority for the safety of the men and the progressive manager takes an active interest in reducing the accidents at his operations. In addition, he is the most important factor in promoting the social welfare of the employees through direct contributions from the company and his personal moral support to any movements along this line. The spirit of the manager, in fact, reacts through the whole organization and determines its general character, for better or worse, according to the individual point of view.

Next in authority under the executive head are the division manager, whose duties and responsibilities are similar to those of the manager himself, and below these we have a large number of department heads, including the mine superintendents, chief engineer, master mechanic, superintendent of construction, electrical engineer, chief clerks, store managers, chief surgeon, etc. Division managers would only be required by the larger companies operating groups of mines at distant points. Quite often the mine superintendent fills this office, having charge of several mines close together.

The superintendent is the real connecting link between the executive head of the company and the men. On him falls the burden of absorbing the interminable differences between capital and labor and endeavoring to compromise these differences and keep the organization running smoothly. The superintendents are mostly men who have served as fire bosses and foremen, though some companies draw most of their men for this position from the engineer-

ing department when competent material is available. The practical man has the advantage over the engineer in having a clearer insight into the psychology of the workman and being a better judge of what constitutes a fair day's work, but the technical man also has certain advantages resulting from his superior education and mental training that cannot be overlooked. In the last analysis the man with the inherent qualities of a true executive, a characteristic that cannot be acquired by training, will make the most capable and efficient superintendent.

The superintendent receives, interprets, and puts into execution the programs outlined by his immediate superiors, reporting back the progress and any untoward conditions that may arise. He has all of the intricacies of the haulage, ventilating, and drainage systems constantly in mind, and is keenly alert to take advantage of any natural conditions that may appear as the mine develops, to effect improvements or economies in these. He must keep constantly and everlastingly after his different foremen in order to keep them keyed up and alive to their various responsibilities and the whole organization tuned up to a maximum efficiency. The accounting systems now in effect quickly reflect the slightest relaxation in effort on the part of the superintendent by an increase in the cost of the coal mined, which he will be called upon to explain. On top of his official duties he is frequently the community arbiter of domestic disputes, godfather at innumerable christenings, and something of a demagogue in general within his particular sphere of influence.

Immediately under the superintendent and directly responsible to him are a number of foremen, including the mine foremen, top boss, tipple or weigh boss, stable boss, electrician, master mechanic, etc. The mine foreman is the real directing head of the mine operations and as such

is the backbone of the executive personnel. Upon him rests the main burden of keeping the mine tonnage up and maintaining the physical condition of the mine and as a general rule all other departments have to give way to him. He is directly responsible for all of the men in the mine, which may mean anywhere from one hundred to four hundred or more, and as these are scattered over wide areas, the task of supervising their different activities is one of considerable magnitude.

As a rule he endeavors to make the round of all the working places at least once a day, inspecting track and roof conditions, listening to the complaints of the miners, and making adjustments for extra work, etc., while at the same time keeping an eye on the main haulways to see that there is no interruption in the steady flow of coal to the tipple. More often, however, he is liable to find himself tied up with some special problems, such as a heavy cave-in on one of the main haulways, a conference with the miners' pit committee concerning an adjustment for special work, an accident to one of the miners, a balky haulage motor, mining machine, or pump, etc.

The mine foremen are usually drawn from the ranks of the more ambitious miners, those having first served an apprenticeship as a fire boss or face foreman in charge of a limited area of the mine. They must necessarily be good executives competent to show an iron hand when the occasion demands, but withal men of sound judgment tempered with an inherent sense of justice and right, and equipped with an inexhaustible store of patience with which to face the endless array of petty annoyances that are a part of their daily life. It is a position that may quickly break the spirit of a man not specially adapted to the work and at best is a thankless job and brings only meager rewards.

Under the mine foreman are the assistant foremen, face bosses, or fire bosses. Where the mine is unusually large, as in the case of the big anthracite collieries and some of the larger bituminous operations, it may be necessary to have several assistant foremen in charge of different sections of the mine or of special kinds of work, such as timbering, etc. Ordinarily, however, the fire boss or face boss is the only assistant the foreman has. The name fire boss is a misnomer, properly speaking, as his ostensible duties are those of inspecting the mine for explosive gas and he should, therefore, be termed the gasman. In very gaseous mines the fire boss makes an inspection of the entire mine, or his particular section, early in the morning before the mine starts to work, usually starting about two or three o'clock, so as to have ample time to complete his round and report to the foreman before the men enter the mine for the day's work. Any sections of the mine that are found dangerous are barricaded off and marked with a deadline, and precautions are usually taken also to warn the men working in that particular section.

The duties of the fire boss are confined more particularly to the matter of ventilation and he is usually held responsible for seeing that brattices are put up as required and that no serious leaks develop in any of the old ones or the ventilation interfered with in any way. He also makes a general survey of the conditions in his section and saves considerable time for the foreman by directing him to matters requiring his particular attention, when he appears in that section. In most of the bituminous mines, particularly the shallower ones, gas is not encountered in dangerous volumes, so that the actual duties of fire-bossing are more or less nominal, though at the same time none the less essential.

The duties of the other foremen immediately under the superintendent are along the lines indicated by their titles. The top boss has charge of all the work around the mine mouth, such as sending supplies, timber, etc., into the mine, and tending to minor repairs; he or the tipple boss will have charge of handling the railroad cars under the tipple, dumping cars of rock from the mine, and so on. The tipple boss is responsible for handling and weighing all the coa at the tipple and seeing that the empty trips are made ready to be returned to the mine. The large amount of electrical equipment and machinery around the modern mine necessitates a local mechanic and electrician at each mine or small group of mines. These men may be assigned out from a central organization but they are usually responsible to the local superintendent.

SPECIAL DEPARTMENTS

The large size of the modern coal company and the introduction of many highly technical and scientific features in the methods of operation have naturally resulted in the development of some very specialized departments. Among these are the engineering department, mechanical and electrical departments, accounting, purchasing, medical, safety, farm, timber, etc. Only the larger companies would have special departments devoted to each of these matters and even they would seldom have departments covering all of the subjects mentioned.

Of these departments the engineering is the most important. There is perhaps no other phase of the operating department where the customs vary so widely as in the extent of the engineering practice. Some companies are satisfied with nothing but the best along this line while others give it only indifferent attention and there are some that look upon their engineering as nothing but a waste

effort and endeavor to skimp through with the minimum expense. Generally speaking, good engineering can effect greater savings than any other part of the operating department; and, vice versa, there is no other department that can occasion the company such heavy losses as poor or inefficient work along this line.

Engineering work at the smaller mines is usually limited to an occasional visit of a surveyor for the purpose of setting up sights by which to drive the underground workings and gather the necessary data for making the extensions on the mine map as required by law. The work has probably been let to a surveyor on a closely competitive basis and at an unremunerative figure so that he is concerned chiefly with getting it off his hands with the minimum effort. The results are inaccurate work that may not only be the source of considerable expense but prove dangerous as well. Careless engineering has taken its toll of both lives and money in the coal industry and been responsible for the loss of large tonnages that might otherwise have been easily recovered.

Occasionally some of the larger companies, operating two or three mines, may contract their engineering work out, but operators in this class and larger usually find it economy to maintain their own engineering department. These departments will vary in size with the number of mines and also with the importance of the work in the eyes of the company officials. The minimum that can be expected is a sufficient number of surveyors and draftsmen to keep the mine maps up as required by the law, any new construction work being generally left largely to a boss carpenter and outside engineers being retained for special problems that cannot be mulled through in some fashion. From this there are gradations all the way up to a very highly efficient corps of expert engineers who

cover the mechanical, electrical, and civil engineering fields, as well as the mining, and who are capable of handling with economy and dispatch any problem that may come up in these respective lines. Such an organization obviously could not be maintained by any but the larger companies and may even appear to be an unwarranted luxury with these but more likely than not it will save its cost several times over in the course of a year's operations.

The average organization for a large coal company would be a chief engineer, who would have in his office some specialists along the lines indicated above, and a number of division engineers located at some central point with regard to the territory they cover. These division engineers would have several men competent to handle the field and mine surveying and one or two draftsmen and would probably keep up the mine maps for their division, though sometimes the notes are sent in to the office of the chief engineer and worked up there. Designs for all new or special work would be made by the chief engineer and referred to the division engineers for execution.

The modern companies with capable engineering forces have adopted very high standards for their mine maps. They require first a systematic method of checking the field work in order to assure absolute accuracy. The mine workings are measured with great care and all variations from the proposed plan of development clearly shown. The original maps are drawn on the best grade of heavy linen-backed drawing paper and are usually filed in a fireproof vault to guard against any possible loss from fire; these maps frequently contain the only record there is of work in the abandoned areas of the mine, which it would be impossible to replace. From these original

maps other supplementary maps are sometimes made for special purposes, such as to show the method of ventilation, haulage, drainage, etc. Some companies also make special maps with heavy lines and have photographic reductions of these so that the mine officials can have a map of convenient size to carry with them at all times in the mines.

Large mines also usually maintain separate mechanical and electrical departments with well-equipped shops at some central point capable of handling all kinds of work, up to building an entire new locomotive. In addition to this each mine will have its own machine shop, blacksmith shop, and carpenter shop for handling the minor repair work necessary. The central shops will have fairly large-sized organizations under the direction of competent men who will also exercise a certain control over the local shops, though the men at these will be more or less responsible to the local superintendent.

The accounting at coal mines has been raised to a high degree of efficiency, particularly since the advent of the Federal tax, which requires the companies to furnish rather detailed statements of their operations. In a large company there is usually an auditor or comptroller who supervises the books of the company and compiles his reports from the statements of the chief clerks at the mine or division headquarters. These clerks have from one or two up to a dozen men in their office and are able to furnish the operating department with detailed figures as to the costs of its various activities. While these local offices are required to coöperate in every way with the operating department, they are frequently responsible only to the executive offices.

The medical department is maintained by deducting a certain amount from the monthly wages of the men, for

which they receive free services for themselves and families. These funds are used to engage a chief surgeon and whatever may be required in the way of assistants. The smaller operations will have only one doctor, the number varying from this up to a comparatively large hospital unit consisting of several doctors, nurses, etc., with ambulance service. Various other activities sometimes originate in the medical department, such as safety first and first aid movements, welfare and sanitary regulations, etc.

Some companies having large areas of surface land in addition to their coal holdings have put the former under cultivation, in order to provide hay and grain for their live stock, or to sell in the market; thus we sometimes find a rather well-organized agriculture department operating in conjunction with the mine. The growing scarcity and high cost of mine timber, particularly in the Pennsylvania fields, has stimulated interest in the matter of reforestation which some of the anthracite companies have taken up extensively. A number of these companies as well as some of the larger bituminous companies have well-organized and well-equipped lumber departments.

CHAPTER V

The Coal Miner

What are the various complexes that go to make up the average mine worker to-day? What are his religious and political tendencies, his social, marital, and domicile status? How and to what extent have the sweeping changes in labor conditions of the past generation affected his thought? What are his earnings, and what, in the words of the U. S. Coal Commission, are "the causes for the sullen hostility which prevails to an astonishing extent among the workers"? In fine, what philosophy lies concealed in this grimy-skinned worker and what does the future hold in store for him?

These are some of the questions that are puzzling the leading economists and statesmen the world over to-day, for it is not in this country alone that we have a coal and labor problem. Labor has arrived at a stage where it is in a position to challenge the autocracy of capital, evidence of which is apparent on every hand. Perhaps the most striking example is the position of the labor party of Great Britain, built up around the nucleus of the miners' union, and now taking over the reins of that most conservative of world's governments. There are definite indications that we are in the midst of radical changes in the existing social order and it is necessary that we keep this thought to the front in analyzing the contributing causes to these changes.

Before going into the details of these matters it is desirable to look back briefly over the past history of the

industry and make a broad summary of the salient points in the existing conditions. A retrospective review of the typical mine worker discloses first a very marked change in type. The dominant type of coal miner in the older days of the industry was the emigrant from the best stock in Europe — the Irish, Scotch, English, and German — all thrifty and intelligent workers of the best class that were readily assimilated into the great American melting pot. Beginning with the twentieth century, or earlier, this class was gradually superseded by emigrants from the less favored countries, Russia and Poland furnishing the bulk, with Italy and Austria next, and the British Isles and Germany contributing scarcely anything to the quota of the foreign born. This element, drawn from the lower levels of oppressed and downtrodden generations and imbued with inherently radical tendencies, to which they are now able to give vent for the first time, is beyond doubt a potential, if not a sinister factor in the social unrest of to-day.

But let us probe a little deeper into the psychology of the present-day miner as compared with his contemporary of a quarter of a century ago and we uncover other fundamental differences that are of interest. It is a well-recognized fact that the efficiency of the mine laborer to-day in no way compares with that of his predecessor; this has been a prolific source of complaint from mine executives of the older school who attribute the difference solely to the change in the class of men. It would appear on closer examination, however, that other factors have an important bearing on both the inefficiency and the marked restlessness which are so characteristic of the present-day situation.

Let us examine, for a moment, the life of the average miner to-day as compared with that of his predecessor a

quarter of a century ago. The latter worked ten hours a day, or from seven in the morning to six in the evening. This meant that he and his family were astir by five in the morning. In the winter he tramped for possibly a mile or better through unbroken snowdrifts to the mine, returning in the evening between six and seven; he lived in perpetual darkness between Sundays and was so exhausted with his day's labor that the women of the family pulled off his boots and scrubbed his back at night, reserving for his aching muscles the most comfortable chair. The lives of himself and his family were committed to the mine to the exclusion of everything else; there were no diversions or enough surplus energy left to organize any. There was seldom any special interest evidenced in his safety — a life being valued at only so many dollars, as a rule — and no interest whatever as to his welfare. In fine, he was but a cog in the big machine which absorbed him mentally and physically, excluding all other interests in life.

The miner of to-day works but eight hours and, protected from the savage bullying of older times by the miners' union, the work is substantially less exhausting. More than likely he lives in a near-by town, free from the depressing atmosphere of the typical coal camp and offering suitable diversions within the scope of his limited purse. Electricity or gas convey him to and from his work and he enjoys the privilege of a washhouse at the mine so that the atmosphere and smell of the mine never invade his home and he passes to and from his daily toil appearing much the same as any other self-respecting workman. Or, if he lives in a camp, there are evidences of a marked interest in his welfare; adequate schools and playgrounds have been provided for his children, a movie, a church, and an auditorium or dance hall. Sanitary con-

ditions have been improved, the iniquitous company store of older days has been largely done away with or made subservient to his interests and he is encouraged to participate in first-aid classes for the mutual benefit of himself and his fellow workers.

Washhouses at the mines have been required by law in a good many of the coal-mining States and while some coal companies make it a practice to do as little as possible

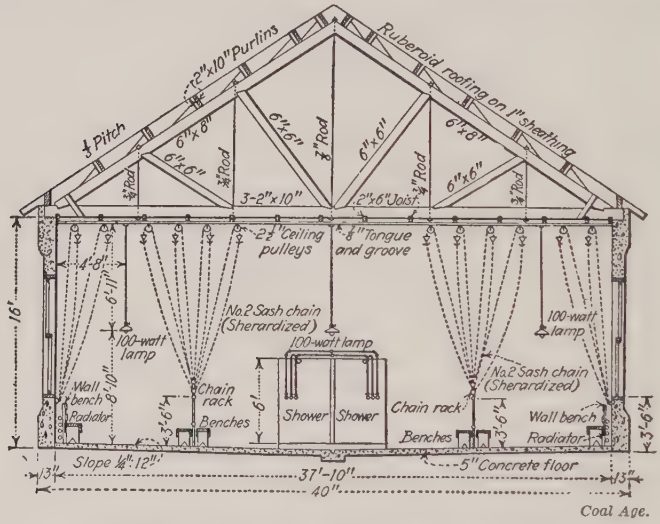


FIG. 54. Cross section of a modern washhouse maintained for the use of the miners.

along this line, others provide very elaborate and comfortable facilities for their men. A cross section of a typical washhouse of the latter type is shown in Figure 54. As will be noted a rather unique method is provided for protecting the miner's clothes from the depredations of his fellow workmen by hoisting them up out of reach. In this way the clothes are dried and well ventilated and each chain is provided with a lock so that no one but the owner can obtain access to them.

Thus we have two sets of widely contrasting conditions upon which we may venture to build up a hypothesis for the turmoil that pervades the industry at the present time. Of first importance is what we may term the changed mental attitude of the worker. The preëminent importance of the mine which formerly absorbed all of his waking moments has given way before other interests which increased leisure have made possible. His work has moved into the background or been submerged entirely under these new interests and thus may we account, in a measure at least, for the decreased efficiency of the modern worker. This increased leisure has also given him more time to devote to the activities of the union and the improvements it has already brought have suggested others that he still wants; the power attained by past victories has only whetted his appetite for more. He has become more self-respecting, more impressed with the dignity of labor and more prone to be assertive of his rights, of which he has a rather exalted idea. His living standards have improved, together with that of his family, the members of which have now found time to engage in minor social activities.

These are some of the conditions through which the average, or better class miner, has been evolved. Like all industries employing large numbers of common laborers, there are many below this standard and others above it; we have endeavored simply to give a composite picture of an average type and the conditions under which he has been developed in order that the reader will better understand the class with which we are dealing.

TYPES OF MINERS

The U. S. Coal Commission compiled some elaborate statistics from the census returns for 1920 which give us

an interesting picture of the type of men engaged in the coal industry. There were in that year a total of 732,441 men employed in the coal industry, of which 147,456 were engaged in mining anthracite coal and the balance were in the bituminous mines. The report deals largely with the anthracite industry on the assumption, it is presumed, that this may be accepted as characteristic of both anthracite and bituminous mines, though it includes some data concerning the latter as well.

We find, for instance, that all but twelve per cent. of the bituminous miners are able to read and write, a rather surprisingly large proportion in view of the fact that a third of the miners were born outside of the United States and more than a fourth of these had been in this country less than ten years. Something over sixty-two per cent. of the miners maintain homes where they work — about half of which are owned by the coal companies — and the domiciles of four fifths are in communities of two thousand five hundred population or less. Some 713 mining communities were examined, of which 66 were reported as among the best company-controlled towns and 82 classed as among the worst. Sons have followed in their fathers' footsteps and become miners in only eleven per cent. of the cases, a rather disappointingly small percentage as compared with other lines of industry and indicative of a trend away from mining.

The foreign-born element among the anthracite workers appears to be considerably larger than at the bituminous mines, amounting to 52.7 per cent. of the total. Over half of these are of Slavic origin from Poland and Russia, and the remainder are from Italy, Austria, Great Britain, Slovakia, Hungary, and Germany, the latter contributing only one per cent. of the total. Only about one half of one per cent. of the foreigners had arrived in this country

during the five years previous to 1920 and about sixty per cent. of them had come over between 1900 and 1915, the balance having been here previous to that time. The most significant feature about the foreigners in the mining fields is their indifference to the matter of becoming American citizens, many of them apparently contemplating a return to the land of their birth when they have arrived at a competence. After making allowances for those ineligible to take out citizenship papers there are still forty-four per cent. remaining who show no inclination to do so.

One of the most troublesome factors with the foreigner in our mines is his inability to speak English. The misunderstanding of instructions or a misconception of duties — frequently quite deliberate on his part — is the cause of a great deal of inefficiency and also materially increases the hazards of mining to this class. The reader must remember that the miner works largely on his own initiative under conditions that require the exercise of somewhat more intelligence than in other lines of industry; if the transference of thought be handicapped by the absence of an adequate medium and this supplemented by a rather low order of intelligence on the part of the worker, a general inefficiency and absence of coöperation result. Thus it is a matter of some concern to know that nearly thirteen per cent. of the foreign-born workers in the anthracite field cannot speak the English language.

The American-born miners form the literati of the mining fraternity, only one per cent. of them being unable to read and write, as compared with five per cent. of the foreign-born from Great Britain and thirty-five per cent. of those from all the other countries, though three and three tenths per cent. of these are able to read. This also is a potential source of inefficiency and danger in the

mines, since it means that no reliance can be placed on the use of signs for directing the men in the underground workings, and there is no assurance that the company's rules and regulations will be read and understood. Some of the more progressive companies have taken active measures to overcome this by establishing night schools for the miners, but the large number of illiterate would indicate that there is still considerable room for improvement along this line.

The anthracite worker does not always maintain his own home, only about sixty per cent. being in this class; in this respect the foreign-born miner appears to be the greatest home lover, 68.5 per cent. of them maintaining their own homes as compared with 43.9 per cent. of the American workers. This can be largely accounted for, however, by the fact that ninety-six per cent. of the foreigners are married as compared with only eighty-nine per cent. of the native-born miners. Only about one third of the miners own their homes and thirty-five per cent. of these are mortgaged to a greater or less extent. The foreigners are also the greatest property holders, thirty-five per cent. owning their own homes as compared with twenty-nine per cent. of the native born. In point of numbers there are more than twice as many foreigners in the anthracite regions who own their own homes as there are Americans.

This is a composite summary of the classes that go to make the bulk of the mine workers. The figures here presented give the broad averages from which there will be variations in different mines and districts. Some nationalities gain a foothold in a certain district, attracting others from the same country and thus become the dominant type in that field. The colored miner is a big factor in the southern and middle southern States and in

the West and on the Pacific Coast the Oriental has made his appearance in the mines.

The average American miner is a steady, self-respecting workman probably somewhat above the average intelligence of his class. There are various inherent conditions in connection with the hazards of underground work that perhaps tend to promote a certain robustness and aggressiveness of manner which has created an unwholesome opinion of miners as a whole. Certainly there is a sprinkling of this element, but the average of the whole is probably about on a level with that of other industries employing a similar class of labor. The philosophy of the average miner's life can no longer be expressed in that one-time popular aphorism, "To live hard, drink hard and die hard."

HOUSING CONDITIONS

One of the most important considerations in the daily life of the miner and his general welfare is the matter of housing. Like the other aspects of the coal industry, the practice of the different companies in this respect also varies over a wide range; conditions run from bad to good, though not from bad to worse as was the situation at one time. We have already pointed out in the preceding section the results of a survey of 713 mining communities as conducted by the U. S. Coal Commission, wherein 66 of these were classified as among the best, and 82 as the worst, leaving the great majority as average.

The Commission is rightly critical of the fact that too many of these are "dreary and depressing places in which to live." But it would hardly appear that it was justified in its terse criticism that "they need not be" without examining some of the underlying causes for this. It quite frequently happens that the financial condition of

the company limits its possibilities in this respect and it is not to be expected that one struggling to maintain its economic existence would tempt possible bankruptcy by an orgy of spending on improved housing accommodations for its employees. While there are undoubtedly financially sound companies that have not devoted the care and attention to the housing that might be expected, an analysis of the "worst" conditions as mentioned in the Commission's report would likely develop adequate reasons therefor.

As a general rule the enlightened coal operator recognizes the importance of providing good living accommodations and attractive surroundings for his employees; the picturesque days when the average mining camp consisted of a single straggling street, lined with dilapidated shanties, inhabited by a gun-fighting population of roughnecks belongs to the very remote past. Aside from humanitarian considerations, good housing facilities bring returns on the investment in the shape of more efficient and more permanent workers who are, at the same time, of a better class. Men of this type settle more or less permanently when satisfied and stand by the company through thick and thin, making the operator independent of drifters, who are always in short supply when most needed.

On the other hand, the operator cannot afford to let his enthusiasm for something exceptional along this line have too full rein or he may be subjected to disappointments. There have been cases where the occupants of some of the better class houses have utilized the bathtub for a coal bin and knocked holes in the brick foundation to provide a domicile for the family pig. These are all factors that must be taken into consideration in studying the housing conditions in the mining communities.

In the well-designed mining camp to-day, recognition is taken of these varying needs and houses built accordingly. First there will be a few substantial, well-built houses, equipped with modern conveniences throughout and comparable with the better type of the modest town house, for the superintendent, clerical forces, doctor, store manager, etc. Next there is a larger group of similar houses along less pretentious lines for the foremen, sub-foremen, and some of the preferred class of men such as the electrician, master mechanic, etc. The balance of the houses which go to make up the bulk of the camp will be divided roughly into two general classes. The first of these will be of a fairly substantial and well-built type, usually of four or five rooms and equipped with running water and possibly a bath and inside toilet facilities. This house is designed for the more permanent miners who appreciate something of a better class and it is usually plastered inside and equipped with some extras, such as a porch, that tend to lift it above the next class below. The inferior houses are designed to meet the requirements of the lower class of improvident miner who would be indifferent to anything above the crudest type of house and probably abuse anything better. These houses may be built somewhat along the lines of the next class above, but would be finished with wood ceiling inside, have outdoor toilets, and be dependent on an outside spigot for its water supply.

The typical mining community is laid out in much the same way as any other small town in rectangular blocks of suitable size and grouped around a central point where the mine office, company store, post-office, and railroad station are located. The creation of the whole community, from the ground up, affords the builders opportunities for the development of original ideas in civic planning which some of the operators have taken advantage of

with excellent results. As rapidly as cinders become available from the power plant, the main thoroughfares are improved and board sidewalks laid at the more important points. Fences are constructed around the better type houses as a rule, and some companies make a special effort to encourage gardening, offering various prizes and furnishing manure from the stables free of charge. Some

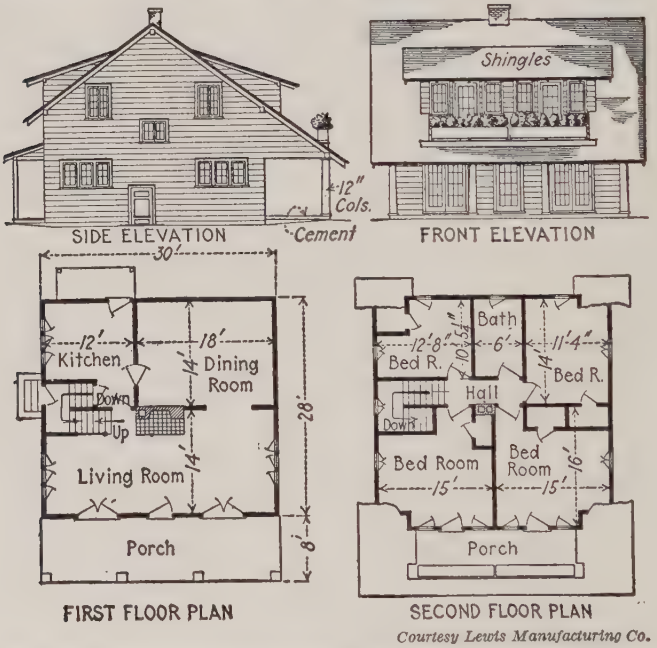


FIG. 55. An example of the better type house for the minor official.

type of sanitary outhouse is used at the better types of camps, with cesspools at the houses having inside toilets, but some of the larger towns of the more advanced companies have put in complete sewerage systems with disposal plants, etc.

An example of some typical mine houses is shown in Figures 55 and 56. These houses have been constructed

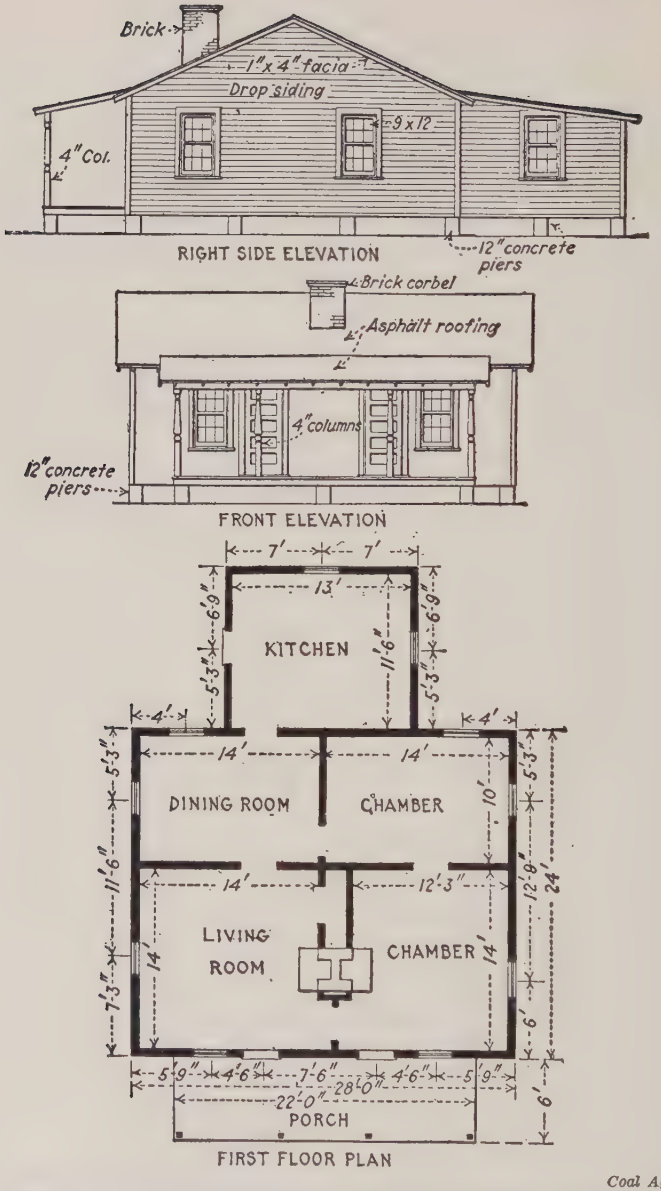
by the coal subsidiary of the Cambria Steel Company at its Slickville mines in Pennsylvania, within the past decade, and are representative of the average or better class of houses in the bituminous regions of Pennsylvania. Figure 55 is the better type house for the minor officials and foremen, the superintendent's house being along this same line with some additional improvements. Figure 56 is a characteristic example of the average miner's house, consisting of four rooms with a lean-to addition in the rear for the kitchen. These houses do not have any inside water connection and rest upon simple concrete pier foundations but their attractiveness has been increased by the addition of a porch.

Operators do not as a rule expect to realize more than a modest return on the investment in good housing accommodations, being content with the improved class of labor which they attract. The rentals for these houses are, therefore, very nominal, the prices per month as given for the above houses in a descriptive article in *Coal Age* in 1923 being as follows: superintendent's house, $25; minor official's house, $15; other types, $6 to $10.

LIVING AND WORKING CONDITIONS

The reader will have gained an insight into the living conditions of the rank and file of the coal industry from the preceding sections describing the types of miners, housing conditions, etc. It is difficult to strike an average type that can be accepted as characteristic of the industry as a whole and still more difficult to place this before the layman in terms that he can grasp. Perhaps this can be accomplished better by a comparison of the miner's living conditions with those of a workman in other industries.

It is not believed, on the one hand, that the worst conditions found in the mining communities are at all com-



Coal Age.

FIG. 56. The typical miner's house equipped with some extras.

parable with those that characterize the lower stratum of the tenement districts in the larger cities, even though the inhabitants of both may be of approximately the same class. This may be ascribed in part to the fact that there is less acute poverty in the mining towns, since they are inherently a community of workers assembled there for that specific purpose and when one is discharged or leaves his position he moves on to another camp. The open spaces of the rural community also tend to promote a better standard of living as compared with the congestion that is characteristic of the overcrowded tenement sections. The sanitary conditions of the mining camps are not above reproach but are probably better than those in the older type of tenements, while the higher rents of the latter would also tend to create excessive overcrowding and promiscuous living, to the detriment of both the health and morals of the inhabitants.

The better type of mining camp, and the better sections of nearly all camps, would undoubtedly present superior conditions to the tenement sections of the large cities and would be more comparable with the permanent industrial communities of New England. These latter have, of course, been constructed with a view to a longer life than the average coal camp, so that a larger expenditure for housing has been justified; the inferior type of mining community would probably average below that of the industrial town of that class, but as we go up the scale they would be more on a par. Again the average or better type mining town might be compared with the average village of a thousand or so population. The latter would enjoy an initial advantage in being removed from contact with an essentially industrial atmosphere as represented at its worst by the mining plant. So far as the housing and the general layout of the two were con-

cerned, they would be very comparable with perhaps a slight advantage in favor of the mining community. The latter would probably have better sanitary conditions on the average, be more advantageously laid out, and have more substantially built houses as a general rule.

While the living conditions of the miners still leave much to be desired, their lot, on the whole, compares favorably with that of the same classes in other industries. It must be remembered that the coal camp has an inherent disadvantage through its location in proximity to the mining plant with its unsightly tipple, rock dump, railroad sidings, etc., while the smoke and blowing coal dust from the tipple make the problem of cleanliness a difficult one. The choice of location for these camps is also limited to the immediate vicinity of the mines; these are frequently in steep mountainous countries, which greatly accentuates the construction difficulties in accomplishing more attractive results.

Contrary to the general belief the mining population is not to be likened to a drifting race of nomads, continually on the move. Community spirit becomes highly developed among the bulk of the miners, particularly where the housing conditions are good and the company has made an effort to promote the welfare of its employees. Loyalty to the company and to the executive personnel is sometimes developed to a remarkable extent, resulting in long years of continued service with the same company, though punctuated perhaps with more or less temporary withdrawals because of some fancied wrong or discrimination. The children sometimes succeed the fathers in the service of the same company and when a superintendent or foreman moves to a new location he frequently takes with him a large portion of the better type of men who have been working with him.

The U. S. Coal Commission conducted a research into the problem of the labor turnover in the coal fields which indicates a favorable stability as compared with the average turnover in industrial lines. The investigation included about one fourth of the first-rate bituminous mines in the country and disclosed an average turnover of 99.9 per cent.[1] compared with a rate of from 115 to 180 per cent. as shown from an analysis of 160 industrial concerns, obtained from another source; the situation in the coal industry shows still more favorably when compared with other industries employing a thousand men or less, the turnover in this class amounting to from 146 to 221 per cent.

The turnover varies over a wide range as regards individual mines, States, districts, etc., the rate for mines varying from 7 to as high as 459 per cent. No particular variations between the bituminous and anthracite industries was evident, but there was a very significant difference between the union and non-union fields. The stability of the workers in the non-union fields varied from nineteen to sixty per cent. as compared with fifty to eighty-two per cent. for the union districts, the term "stability" being used as opposed to "turnover." This, of course, is due largely to the protecting influence of the union organization, though it might also be interpreted as indicative of more favorable conditions generally in the union fields. The turnover is less in the case of the more skilled workman, as might be expected, the proportion of machine runners being 76 per cent. as compared with 110 per cent. for the loaders.

[1] The percentage of turnover is computed from the number of total separations in the course of the year and the average number of employees; a company employing an average of one hundred men during the year, seventy-five of which positions it was necessary to refill, would be rated as having a labor turnover of seventy-five per cent.

A certain turnover in labor is essential if the men are to be kept tuned up to a reasonable efficiency, but just what is a desirable percentage is a matter that is still open to discussion. Shifting wage scales in the non-union fields are, of course, a factor with the migratory classes who will drift on to new fields with every rumor of increased wages. Dull and active periods may also be a factor, though the report of the Coal Commission is somewhat contradictory in this respect. It states on the one hand that it is the opinion of the non-union bituminous operators "that men move more quickly if work becomes slack" and in the anthracite report it says, "When jobs are scarce men do not readily give up a position to seek another, and the turnover at such a time is low."

Let us now glance briefly at the daily routine of the rank and file that go to make up the bulk of the mine workers. In the early morning we find the miner gathered with a hundred or more of his fellow workers at the mine mouth, dinner pail in hand ready for the day's labor. On his head is the regulation close-fitting miners' cap of heavy canvas which holds the carbide or storage battery electric lamp. His clothes are a suit of overalls or some cast-offs from his wardrobe or, more likely, a combination of the two; unless he has had a "change" that morning they smell frankly of the dank underground atmosphere though he is happily unconscious of the fact. His feet are incased in heavy shoes substantially reinforced and probably hobnailed, except when he is working in a wet place, when some form of the more expensive waterproofs are required.

At a shaft mine the men are lowered rapidly in groups of about eight and at slope and drift mines a special man-trip is provided, particularly where the distances in the mine are great. Having arrived within the mine the men

split up into groups and proceed to their respective tasks. The miner enters his room, sounds the roof for any possible weak spots that may have developed overnight and clears the track of any loose rock that may have fallen. If an empty car is available and coal ready for loading, he tends to this next; being paid on a tonnage basis he obviously must get out all the coal he can and if his car is not loaded when the driver arrives, he loses his "turn" and has to wait for the next trip. These matters attended to, he then turns his attention to the task of mining or possibly some repairs to the track, setting props, etc. If machines are used, he has to wait for this to arrive, but if it be pick mining, he can proceed with making his cut, drilling his holes for blasting, etc.

Thus he occupies the day, being chiefly concerned to see that the driver or motorman, as the case may be, does not cheat him out of a "turn"; this frequently results in heated arguments and violent recriminations, or if he be more diplomatically disposed he may endeavor to subsidize this important functionary by means of small presents. Beginning sometime after the noon hour the miner's "turn" becomes more infrequent for various causes and he usually gets his last empty car an hour or so before the theoretical closing time for the mine; experience has shown him about when he has received his next to last car, so more than likely he may leave the mine after loading this, knowing that the driver will have a fresh empty in place for him to load the first thing in the morning. This freedom of action as compared with the petty restraints of the ordinary laboring job is one of the distinctive features of the miner's work.

Besides the miner there will also be a force of laboring men, engaged in hauling the coal and maintaining the mine, who are paid on a *per diem* basis. Underground

we have the drivers or motormen, trackmen, timbermen, pumpmen, machinemen, etc., the names of which indicate their respective duties. The machinemen are more or less skilled mechanics and belong to the élite of the underground workers. Trackmen are engaged in the maintenance and extensions of the mine tracks; the timbermen are doing the same in their field. The drivers and motormen are usually drawn from the younger element and the pumpman probably has nothing at all to do aside from occasionally oiling or regulating his pump. On the outside are the hoisting engineer at the slope or shaft mine, firemen for the boiler plant, tipple crew who dump the mine cars and shift the railroad cars under the tipple, a small crew of machinists, carpenter, blacksmith, stable boss, etc. The number of daymen required in these various occupations, both inside and outside, depends on the size of the mine and the condition it is in, some of the older plants being badly run down and requiring more or less continual repairs to keep them operating.

THE MINER'S EARNINGS

There is probably no one aspect of the coal industry shrouded in such a maze of uncertainties, subject to such wide differences of opinion and withal of such vital importance to the operator, worker, and consumer as the question just what the miner's earnings are. On the one hand we have the operating interests propounding theories backed by voluminous statistics that tend to indicate abnormally high rates of compensation; on the other side we have the miner's union submitting equally convincing data to prove that the earnings are not adequate to permit the miner to live at the accepted American standard. In the meantime the consumer sits patiently — or impatiently, as the case may be — on the side lines,

suffering from constantly recurring coal shortages and increasing prices while the other two factors exchange futile recriminations.

As would be expected with a problem of this importance the U. S. Coal Commission conducted an exhaustive investigation into the various merits and demerits of the controversy. Besides a very comprehensive survey of the anthracite field, it made an analysis of the earnings of 332,668 workmen at nearly two thousand different bituminous mines scattered through twenty-three coal-producing States. The finished report is probably the most voluminous compendium ever prepared on the labor question in the coal or any other industry and furnishes an inexhaustible store of scientific and technical data upon which the future economists may build theories. That it is not of great significance as offering a solution to the immediate problem of whether or not the miner is receiving an adequate wage the Commission naïvely recognizes when it says the report has not been "prepared for the casual reader, but for the serious student who desires to study all the elements in the industrial situation" and, "Nothing is to be gained in either accuracy or truthfulness of presentation by endeavoring to make appear simple that which is essentially complex", so that the report is turned over to the tender mercies of "competent students of our industrial and social problems" for interpretation.

While it is not within the scope of this modest volume to cover all of the issues involved in this great controversy between capital and labor, there are certain fundamental points, recognized by both sides alike, that will do much to clarify the atmosphere. These points are based on both an acceptance and a contradiction of the claims of both parties; thus, whatever one's sympathies may be in the matter, it must be admitted that the *per diem* wages of

the miner are excessive as compared with those in other equally hazardous industries where men of the same average skill are employed. On the other hand we must also admit that the average earnings of the miner for the year are not commensurate with what is regarded as adequate to maintain the American standard of living.

Accepting these facts as axiomatic, we must then look deeper into the question for the cause of the trouble. This we find to be due to the intermittent character of the miner's work, the effects of which we have already commented upon in other parts of the book. Thus while the miner is paid a comparatively high wage, his employment is so irregular that the gross realization at the end of the year falls substantially below what it would be in any other industry with an equally high wage scale. Whatever other arguments may be advanced by either party to this controversy, this is the real crux of the situation. If the coal industry is going to carry an excess overhead of around twenty thousand more men than is actually required to produce the coal now consumed, it is obviously assuming an enormous burden that must inevitably revert back to the consumer in the increased cost of production.

The study of the miner's earnings by the U. S. Coal Commission was initiated on such a broad scale that it was impossible to complete the work and summarize the results, but the statistician in charge of assembling and correlating these data presented an interesting summary in a paper before the American Academy of Political Science. This summary is perhaps one of the most comprehensive analyses of the miner's earnings, as viewed in its broader aspects, that has ever been prepared and we are indebted to it for much of the following data on this subject.

We find from this summary that the average earnings

of the anthracite contract miner [1] during the year 1921, when he worked two hundred and fifty days, was $1,922. This was an off year in the bituminous fields, the union mines working only 134 days and the non-union 151 days; the average compensation of the miners in each of these was $1,034 in the union field and $1,051 in the non-union mines. The year 1920 was a more normal one in the bituminous fields, the union mines working 219 days in that year and the non-union mines 221, the average compensation for each being between $1,750 and $1,800. On the basis of the actual time worked the two fields thus show a remarkable similarity, the anthracite miners having worked about one month longer and having received about $156 more wages. These figures are for all classes of miners and if we exclude those who only worked part of the year and who are necessarily less efficient for various reasons, the earnings are substantially better. Thus in 1921 the bituminous miners who worked the full year received about $1,425 to $1,450 and in 1920 they received from $2,025 to $2,075.

Laborers employed by the contract miners in the anthracite regions change their positions so frequently that it is difficult to arrive at an accurate estimate of their earnings. The Commission's figures show the earnings of this class to be $1,200 for the two hundred days they are estimated to have worked in 1921. In view of the fact that the supply of laborers is nearly always inadequate it is believed that they must have worked the same number of days as the miners themselves and on this basis and at a daily rate of $5.87 their income would have

[1] The term "contract miner" as here used is equivalent to that of miner in the bituminous fields, the difference being that the miner in the anthracite districts always employs one or more laborers on a *per diem* basis to assist him in his work.

been $1,468 for the year. The average earnings of both the miner and the laborer for the year 1921 was $1,780.

The average daily wage of the bituminous union miner and the anthracite contract miner (also union) for the year 1921 was found to be between $7.75 and $8, the difference between the two classes amounting to only four cents. The daily earnings of the non-union bituminous miner, however, is somewhat below this, being between $7 and $7.25 per day.

It will be remembered that the groups so far discussed belong entirely to the tonnage class of workers as distinguished from the daymen, whose wages will now be taken up. The tonnage workers constitute almost three fifths of all the employees at the bituminous mines and slightly better than two fifths of those at the anthracite mines.

In analyzing the wages of the daymen employed at the mines we must first remember that there is a wide difference between the anthracite and bituminous mines in this respect. This difference is due largely to the excessive number of outside men engaged in the preparation of the coal in the anthracite regions, eleven per cent. of whom are slate pickers, consisting mostly of boys. Excluding these boys, the average earnings of the outside employees in the anthracite industry for the year 1921 was $1,320, based on an average of 293 eight-hour days. In the bituminous industry the average compensation of the outside employee at the union mines for the same year was $1,445 and the number of days worked 207, the same figures for the non-union mines being $1,200 and 218 days respectively. The earnings of the outside employees for the more active year, 1920, are naturally somewhat better, being between $1,850 and $1,875 at the union mines and $1,700 to $1,750 at the non-union. Thus it will be ob-

served that even with the lower-paid element in the anthracite regions excluded, the outside employees there earn somewhere between $400 and $500 less than the same class in the bituminous fields.

The inside employee is, of course, better paid than the outside worker. The anthracite inside employee averaged $1,480 in 1921, working 290 days. The inside union worker in the bituminous fields averaged 175 days in the same year and earned $1,293, while his contemporary in the non-union fields averaged 189 days and earned $1,125; the average earnings of all inside men in the bituminous field for 1920 was $1,600. Thus while the inside man in the anthracite fields earns on the average somewhat more than his compatriot in either of the bituminous fields, he is at the same time obliged to work something over a hundred days more or about the equivalent of four months.

The figures for all the daymen so far considered have included the class of intermittent workers, which pulls the average for the various groups down below what it is for the steady worker. Considering the full-year workers only, the average earnings in the bituminous industry for both the inside and outside men together in 1920 was $1,850.

The average daily earnings of the various classes of workers in both the anthracite and bituminous industries, on the basis of an eight-hour day, were found to be as given in the table on the next page.

It will thus be seen that there is a difference of from $1.75 to $2.25 per day in the wages of the bituminous and anthracite daymen, but in spite of this unfavorable differential against the anthracite worker he earned on an average about $200 more in 1921 than did the bituminous day worker. We have already mentioned the remarkable similarity between the anthracite and bituminous tonnage

miners on a daily basis, but the former has so much more steady employment that his earnings for the year far exceed those of the bituminous miner.

AVERAGE WAGES PAID DAYMEN FOR AN 8-HR. DAY IN THE YEAR 1920

OUTSIDE				INSIDE			
	Anthracite	Bituminous			Anthracite	Bituminous	
		Union	*Non-union*			*Union*	*Non-union*
Blacksmith	$5.35	$7.57	$6.36	Bratticeman	$5.19	$7.42	$5.96
Carpenter	5.27	7.14	5.94	Doortender	3.18	4.48	4.26
Engineer	4.98	7.29	5.97	Driver	4.67	7.47	6.22
Fireman	4.76	6.95	5.41	Pumpman	5.10	7.14	5.53
Stableman	4.28	6.07	5.07	Timberman	5.89	7.52	6.26
Laborer	4.26	6.55	4.58	Tracklayer	5.22	7.35	6.09
Miscellaneous	4.38	6.74	5.37	Laborer	4.92	7.16	5.08
				Miscellaneous	4.96	7.41	5.99

In a broad general survey of the earnings of the tonnage miners in both the anthracite and bituminous industries, we find a few in each of these fields with incomes of from $3,600 to $4,000 per year. Anthracite miners earning $3,200 number two hundred or less, while the bituminous miners in this class are still inconsequential. In the $2,800-class the number of anthracite miners has increased to around four hundred and the bituminous miners have begun to pick up, numbering about one hundred. The number of bituminous miners earning $2,400 a year is about two hundred and the anthracite one thousand four hundred. At the $2,000 level we find the widest difference, the anthracite miners numbering two thousand five hundred with around nine hundred in the bituminous fields.

It will be seen from these figures that the number of miners earning excessively high wages is comparatively limited. It is quite true that opportunities occur where miners of exceptional ability and enterprise are able to make unusual earnings, but this is no more remarkable

than where some workman in construction lines takes a small contract upon which he is able to realize equal or even larger profits. Statements pointing to a miner's earnings of $400 and $500 per month must, therefore, be accepted with reservations until all of the conditions under which these were made have been ascertained. They cannot be accepted as characteristic of the industry or of any particular mine and at best are only misleading.

It is of interest while on the subject of wages to make a brief comparison of the situation here and abroad. This comparison can hardly be accepted as a basis for adjusting the miner's wage here because of the wide difference in the cost of living, but it is of economic importance as showing the disadvantage the American coals are laboring under in the export markets.

According to an article in *Coal Age* at the beginning of 1924, the average daily wage paid the 1,129,539 men engaged in the British coal industry in 1922 was $2.29 (based on a normal rate of exchange of $4.87 per pound sterling) and the average number of days worked was 251. The average earnings per day varied from $1.85 in the South Staffordshire and Shropshire districts to as high as $3.11 in the Kent district. The total average earnings for the year and for all districts amounted to $609.24, these varying from a minimum of $461.41 in the Somerset district to a maximum of $790.38 in the Kent district.

France imports a large percentage of her fuel supplies and is, therefore, no factor in the export trade, but an examination of her wage scale is of interest as indicating the extent of competition that may be expected in her domestic markets. The average wage of the French miner at the working face in the latter part of 1923 was $1.33 per day of eight hours (computed on the basis of 5.32 cents per franc) and the outside worker received an

average of ninety cents per day, most of this work being done by girls. Children from thirteen to fifteen years old earn ten cents to twenty-six cents per day and the average for all men and boys about the mines is ninety cents per day.

THE MINERS' UNION

No right-thinking man of this day and age who is familiar with the past history of the coal industry can seriously question that it has only been through the medium of organized labor that the life of the miner has been lifted out of a condition little better than serfdom. The U. S. Coal Commission recognized this fact, stating, in substance, "The history of the past 30 years affords conclusive evidence that the United Mine Workers of America has been the potent agency in the betterment of the miners' working conditions, and it is necessary to-day for the protection of the standards that have been attained." Viewed in the humanitarian light of our present-day standards, even the most ardent anti-unionist must admit the inherent brutality and uniform injustice to which the miner of former days was subjected.

Approbation of the fundamental principles of unionism in general, however, must not be construed as unreserved approval of all its policies and the methods by which its leaders have endeavored to make these policies operative. We may grant that similar strong-arm tactics have been employed by both sides to the controversy when critical matters have been at issue, but even this does not justify the miners' resorting to these extreme measures. The miners' union has much in its history that it would be glad to eradicate.

The union has produced some brilliant leaders, such as Mitchell of a decade or two ago and Lewis of the present

day, men who handled their difficult positions with a tact and diplomacy that must be admitted by all. It is to be regretted that the subordinate officials were not men of the same caliber, but the composition of the union membership is such that it was inevitable that a certain proportion of the more radical element would be elected to positions of responsibility in the organization. It would be impossible to picture the degree of stupidity and stubbornness that some of these district leaders exhibit to one who has not had occasion to sit in a conference with them; whatever one may have to say of the representatives of the capitalistic group they, at least, have a polished finesse in admitting a fact when proved beyond all peradventure, but some types of labor leaders make it a practice never to admit anything and are obviously intent only on exacting the last pound of flesh possible irrespective of the justice of the case. It is this element in the union which has thrown the organization into ill repute and been such a disturbing factor in the negotiations with the operators.

UNIONISM IN THE ANTHRACITE FIELDS

There was a very active and strong labor organization in the anthracite fields in the seventies of the last century when the better class of miners from Great Britain and Germany were the dominant type there, but this was broken up about 1880 by a combination of circumstances. One of these was the large influx of workers from the less desirable countries who were willing to accept indifferent wages and another was the heavy overproduction of coal and consequent slow working time at the mines. A partial reorganization of the field was effected in 1900 and by 1903 the union had become strong enough to force the appointment of the Anthracite Coal Strike Commission to settle their differences with the operators.

This commission awarded the contract miners an increase of ten per cent. in the tonnage scale and reduced the working time of the company men from ten to nine hours a day without any reduction in their wages. A sliding scale of payment on the tonnage basis was also introduced, providing for an increase of one per cent. in the rate for every increase of five cents per ton in the selling price of the prepared grades above $4.50 per ton. The next decade was uneventful in the history of the anthracite union with a possible exception of a general stiffening in the organization. In 1906 there was a strike of five weeks, which ended with an agreement to extend the award of the Anthracite Strike Commission for another three years and at the end of that time it was extended for a second three years on the same basis. In 1912 there was another five weeks' strike, which resulted in a general increase of ten per cent. in the miners' wages and an agreement covering the next four years.

In 1916 another four-year agreement was entered into and the working time for most of the daymen reduced to eight hours. The daymen also received a three per cent. increase in wages, or about the equivalent of sixteen per cent. after making allowance for the shorter day. The tonnage workers were granted an increase of seven per cent. at this same time. The great pressure of war business became evident shortly after this last agreement, so that it was superseded by a series of supplementary agreements giving the miners still further increases during the next few years. Two of the supplementary agreements were made in 1917, one in May and the other in November, followed by a third in November, 1918. The total of these agreements brought the contract miner's wage up forty per cent. above the agreement of May, 1916, and increased the wage of the daymen from around $1.80 to $2.20.

A fourth supplementary agreement was made in September, 1919, giving the miners another advance and this was followed by the great five months' strike in 1920. This strike was finally settled by a commission appointed by President Wilson, who gave the contract miners an increase that brought their wages up to about sixty-five per cent. above the agreement of May, 1916, the daymen receiving an increase of about seventeen per cent. above the last of the supplementary agreements. This agreement was continued until April 1, 1922, when there was another five months' strike which terminated in a *status quo* and the same agreement was extended to October 1, 1923. The strike at that time was settled by the intervention of Governor Pinchot, who awarded the miners a general increase of ten per cent. above the existing rate at that time.

THE FIGHT FOR THE CLOSED SHOP

Unionism of all kinds relies for its main strength on the principle of the closed shop. Where an industry is only partially organized with non-union and union employees working side by side, the prospects for bringing about a complete cessation of activities is remote. It is upon this deadly power of the union to completely paralyze the productive resources of an industry that it depends to force recognition of its demands, either through financial losses to the owners or inconvenience and hardship to the consumer. Since the beginning of time, therefore, the question of the closed shop has been one of the most vital issues at stake in all of the labor controversies, and nowhere has it been contested with such sanguinary results as in the coal fields.

The non-union operators admit, in principle, the right of the workers to organize for the purpose of collective

bargaining but they also maintain that they are not obligated to employ union workers. Appreciating the fact that the union would spread rapidly if once admitted to their mines, they therefore refuse to employ union men, ostensibly — and with some justice, of course — for the reason that they are trouble makers. In justification of the closed shop principle the union officials claim that it is not right for the non-union worker to participate in the benefits derived from the union in the shape of improved labor conditions and increased wages unless he assumes his share of the expense in obtaining these by becoming a member of the union and paying the dues.

Thus we have two opposing schools of opinion, not subject to adjudication through legal processes and both founded on sound American principles of justice and freedom of action. Both sides have their open shop but that of the operators is open only to non-union men and that of the mine workers' organization is open only to union men. There are no intermediate grounds upon which to build a suggestion for a compromise that would have any prospects of being acceptable to either side, so the inevitable result has been a series of bitter struggles for supremacy that have been the occasion of some of the most tragic episodes in the annals of the industrial life of the country.

This problem has grown to vast proportions and become one of the leading issues upon which both sides have endeavored to influence public opinion in their respective interests. In pursuance of this plan accusations of the gravest kind are being made. The operators claim, for instance, that the United Mine Workers will stop at nothing to force the unionization of all the coal mines in the country, in proof of which they point to the large sums of money the union has expended in endeavoring to organize the non-union districts of West Virginia;

they claim also that the operators in the unionized fields have aided and abetted the efforts of the union to organize the non-union districts in order to eliminate the unfavorable wage differential against the union fields.

On the other hand the union claims that there is a concerted effort being made by the operators in the non-union fields to destroy the United Mine Workers of America and they are able to cite instances of unlawful conduct and statements made by these operators that tend to support this contention. One cannot read all of the proofs as submitted by both sides without being impressed with the fact that they are both fundamentally true, though to what extent these machinations have been carried on by either side is a matter of conjecture. This, too, is the impression conveyed by the rather indefinite findings of the U. S. Coal Commission, which, in so far as the legal aspects of the matter are concerned, "chooses rather to give those who are charged with violation of the law the benefit of doubt as to criminal intent."

One of the most spectacular struggles over the matter of the closed shop was that of the tragic and brutal massacre of twenty-five non-union workers at Herrin, Illinois, in June, 1922. As this presents a more than ordinarily interesting example of union psychology and the sincere, whole-souled support accorded it by enlightened and well-balanced peoples in the organized districts, it is of interest to examine the conditions surrounding this unfortunate incident in some detail. To comprehend how such incidents as these can be condoned the reader must first understand the sacred trust which the miner puts in the inviolability of his rights. We are all more or less familiar with the inherent trust placed in the sacred rights of property and these are of perhaps less significance to the miner than the principles upon which his union is

built, of which the issue of the closed shop is one of the most vital. Any blow struck at the union institutions is resented by the true union miner with a ferocious aggressiveness that would at once remove any doubt of the sincerity of the miner's attitude on this question.

The scene of the Herrin massacre was a new strip-mining operation in Williamson County, Illinois. The owner of the mine had obtained permission of the union to continue removing the overburden during a suspension in the State, promising in return that he would not mine any coal. When this work was completed he discharged the union men who had been engaged on it, imported a crew of non-union men, together with a force of armed guards organized by a detective agency, and started mining coal. For a week or so there were minor hostilities on both sides, the miners turning back many of the non-union men who were imported and establishing pickets at the mine. The mine guards had in the meantime made themselves obnoxious to the community by stopping people on the road, insulting women, etc., and it was reported at one time that the local sheriff had been killed while attempting to interfere with their unlawful activities. An effort was made to call out the State troops and the sheriff visited the mine once but refused to interfere in any way. He was at this time a candidate for the office of County Treasurer and was later elected by a vast majority.

Matters continued thus until Wednesday, June 21, when a party of non-union miners, who were being brought in overland in a truck, were ambushed and one killed and three others injured. Following this the miners raided hardware stores at Herrin and Marion, taking all the firearms they could find and telling the proprietors to charge them to the local union. They then surrounded the mine and in the course of the afternoon three of the union

miners were shot and killed; one of these was a favorite character in the union and it was said that he was shot while attempting to negotiate with the non-union miners for a parley. The following morning firing was resumed. The non-union men claimed that the miners fired on a white flag which they hoisted, but the latter claim that the guards were firing from under the flag. A parley was arranged shortly, however, and it was agreed that if the non-union workers and guards would leave their arms at the mine they would be given safe conduct out of the county. It appears certain that this promise was made in good faith, but in the meantime hundreds of new recruits from the surrounding country had been arriving and rumors were started that the State troops were on their way to the scene.

As a result of this report and others that were circulating, the crowd soon got out of hand and before the party of non-union men had proceeded a mile from the mine the superintendent was taken out of line and killed. Shortly after the forty to sixty prisoners in the group were lined up against a fence and told to run, being shot down as they did so, though some few escaped, many of whom were hunted down and killed later. Six of these latter were tied together with ropes around their necks and marched through the town of Herrin — a progressive small-scale city with paved streets — to the cemetery and there shot or had their throats cut, though it is strange to relate that one of these survived to testify about it later. It is not known just how many were killed, the best estimate being twenty-five.

Let us now examine the effects of this upon the community. First, it is necessary to point out that the residents of Williamson County represent a typical American community of the better class. They have an excellent rec-

ord for patriotism in the World War, are well educated, deeply religious, and the residents own more automobiles than those of any other county in the State except Cook, in which the city of Chicago is situated. About ten per cent. of the residents are foreign born but there is no evidence of communistic activities and the socialist vote in the county is nil.

The sentiment of the people is first reflected by endorsing the quiescent attitude of the sheriff by an overwhelming majority at the next election. Next the verdict of the coroner's jury read that, "the deaths of the decedents were due to the acts, direct and indirect, of the officials of the Southern Illinois Coal Company", this latter being the company that owned the mine at the time. And finally, in spite of the fact that different aspects of the horror must have been witnessed by hundreds of persons, many of whom undoubtedly represented the best element in the community, it was not possible to secure a single conviction of any who participated in it. That it was at least condoned by the union is evidenced by the active part it took in defending those accused with complicity in it and also from the fact that it later bought the mine from the owners at about three times what it had cost them. It must not be inferred, however, that the whole plan was premeditated or even contemplated; the U. S. Coal Commission made a very exhaustive investigation into the matter and expressed the opinion that, "Although the tragedy might have been prevented, it finds that the union officials never anticipated it would happen."

Thus we have an instance of the sovereign power of a great State being flaunted when the issue of unionism was at stake. That the great majority of the people believed the very existence of the miners' organization was threatened there is little room to doubt; many of these undoubt-

edly believed they saw in this the initial step in a move that would ultimately crush the union and bring about a resumption of the pre-union conditions when men worked ten hours a day in gas-filled rooms, frequently in water halfway to their knees and all for $1.25 to $2 per day. The most significant feature of the whole, however, is the passive attitude of the State officials, an attitude that is strongly suggestive of an inherent sympathy with a lawless and bloody massacre the like of which has seldom if ever been witnessed in a law-abiding community before.

If one may be permitted to paraphrase an old patriotic toast, it is clearly a case of "Our Union! . . . may she always be in the right: but our Union, right or wrong." The issue of the closed shop is one that has clearly been understood by those in the mining communities, even when they are not members, and those who do belong to it are evidently prepared to fight for this principle to the death.

ATTEMPTS TO UNIONIZE THE WEST VIRGINIA FIELDS

The persistent attempts of the United Mine Workers of America to unionize the coal fields of West Virginia, and the counter measures of the operators in that field to prevent their doing so, have resulted in one of the most titanic struggles between capital and labor in the history of the country. Both the operators and the union have poured incalculable sums of money into the fight, have disregarded laws, civil rights, and elementary principles of humanity and when the occasion has demanded, have spilled blood with a reckless hand. Obviously there is something out of the ordinary back of a struggle attaining to these proportions, and it is of interest to examine first some of the fundamental issues at stake.

The aggressive has, of course, been assumed by the

union, there being several reasons why it has become necessary for them to organize these fields. First, we have already seen in the chapter on The Miner's Earnings that the scale of the union worker almost invariably exceeds that of his contemporary in the non-union fields. This naturally throws an increased burden on the cost of production in the unionized fields, placing these operators under a disadvantage in times of a dull market and reducing their earnings even under the more favorable conditions. Under the circumstances it would be contrary to the dictates of human nature if the union operator did not make an effort to eliminate this unfavorable differential against him; appreciating the fact that he could not destroy the grip of the union in his own field, the only other method of procedure left was to assist the union in organizing his competitors' mines. To what extent the union operators extended their assistance in this matter is problematical; that there was at least something in the nature of an understanding between them and the miners is clearly evidenced by one of their early agreements in which the point is definitely mentioned.

Besides this pressure from the union operators to get the non-union fields organized, the United Mine Workers have undoubtedly felt that these unorganized fields are a more or less constant menace to the very existence of the union. The union operator is naturally restive under existing conditions and would be quick to seize upon any chance condition that might arise to enable him to throw off the yoke of unionism. The very large production that the non-union mines are able to put on the market whenever there is a strike in the union fields also breaks down the efforts of the union officials to effectively paralyze the productive capacity of the country and thus more quickly attain their ends. Other conditions also

tend to make these unorganized fields a constant thorn in the side of the union officials, such as the increased earnings of both the non-union operator and miner when there is a strike in the union fields, the indirect benefit the non-union worker derives through increases in the union scale, which are usually made the basis for payment in the non-union fields also, etc. It will thus be readily seen what importance the union officials attach to the necessity for effecting an organization of the non-union districts.

The principal stronghold of the non-union operators lies in southwestern West Virginia and eastern Kentucky, a picturesque, mountainous country, inhabited by a primitive class of back country people more or less accustomed to taking the law in their own hands, the whole forming an admirable setting for the deadly guerrilla warfare that has characterized the efforts of the United Mine Workers to secure a foothold in the district. The operators own or control the lands in the affected territory to such an extent as to make it virtually impossible for an outsider to enter any of the fields without becoming a trespasser within the definition of the law, and effective organizations have been built up for dealing with any undesirables such as labor organizers that may appear.

This is accomplished by means of what is known as the "mine guards", a system that has evoked the most bitter criticism from the United Mine Workers. This system developed out of the need of more officers than the meager taxes of the relatively poor sections would support; the country is rather lawless at best and when abnormal conditions developed over labor controversies the supply of deputy sheriffs to protect the mine properties was clearly inadequate. As a result the operators undertook to have men officially deputized whom they would pay themselves; in deference to the popular protest against this

action they then agreed to loan the necessary money to pay these men to the county and this is now the practice. There is no evidence that any of these loans have ever been repaid or that the operators are pressing for payment. The system is iniquitous and opposed to the very fundamental principles of the American government and has been admitted as such by the Governor of West Virginia.

Under this system nearly every camp has its duly authorized deputy sheriff, who is also usually serving in some minor official capacity at the mine. His principal duty is to keep informed on any strangers showing up in that vicinity and to ascertain their business; if this is found to be objectionable he is then to devise ways and means for discouraging the newcomer's presence, which can usually be readily accomplished by bringing a charge of trespass against him. It will thus be seen that a union organizer would have little chance to initiate his activities under such conditions.

The operators have also secured a favorable interpretation of the law governing evictions from the company-owned houses that has done much to further their cause and hamper the activities of the union organizers. The courts of West Virginia have ruled that the relation of the tenant and landlord do not exist in the case of these houses since they are used exclusively for the housing of the company employees, and the relation is, therefore, more that of the master to the servant. Occupancy of the house is thus contingent upon continued employment in the service of the company, the same as would be the case of a servant in the house, so that when the miners went on a strike they were automatically dispossessing themselves from their domicile. Under these circumstances it was necessary for the miners to move out into

tents, if any land not owned or controlled by the company were available.

In other instances miners are required to sign leases for their houses by which they practically relinquish all control over their social life. An example of this is a lease adopted by a company in Pennsylvania which provides, in substance, that the miner will allow no one on the property other than members of his family, physicians, draymen to move him in and out, and the undertaker.

Such practices as these would seem to alienate any grounds for sympathy with the operating interests, but when we come to examine this side of the case we find he has not been altogether without justification in his actions. In the first place, the non-union operator questions whether his employees desire unionism and declares that he is not going to stand idly by and see it forced upon them irrespective of their wishes. There are undoubtedly miners who leave the organized fields because they are not in sympathy with the union activities and do not care to pay dues into the organization. The U. S. Coal Commission admits the element of uncertainty surrounding this question and is of the opinion that it could only be decided by a secret ballot of the miners in the affected territory.

There is no doubt that the arrogant attitude of the organizers who have been sent into these fields in the endeavor to organize them has excited the general hostility of many of the local residents in addition to that of the operators themselves. The operators also resent the alleged agreement between the union and the operators in those fields whereby the former is pledged to organize the non-union fields. The non-union operator feels keenly that these different practices of the union represent the depths of iniquity and that he is fully justified in resorting to any methods available to defeat the machinations of

the union organizers. There is no doubt of the determination of these non-union operators to fight this issue out to the bitter end and in most instances he must be given credit for absolute sincerity in his beliefs.

The non-union operator also takes the position that he is a public benefactor in taking this stand against the spread of unionism and in support of this points to the fact that he is the only source of supply when there are strikes in the union fields. He also calls attention to the tremendous power the union would be able to exercise over the welfare of the country at large if it were able to perfect its organization in all the fields; in fact, he protests stoutly that his battle is the public's. He also points out the great inefficiency in operations subjected to the petty rules established by the unions and claims that this materially increases the cost of production. In addition to these rules the unions are interfering in other lines that tend seriously to embarrass the operator. As an instance of this, a certain company operating half a dozen mines receives an order for a certain grade of coal that can only be produced at one mine; the market is slow, with the mines working one or two days a week, so the union, in order to equalize the working conditions at all the mines, has decreed that they work in rotation. As the order cannot be filled in the time specified under these conditions it is lost, to the detriment of both the men and the company.

The unions have made many desperate and partially effective efforts to organize the non-union sections of West Virginia and the surrounding country and unless some effective means for a compromise is reached these efforts will undoubtedly be resumed. In spite of the handicaps they are working under, the indications are that they will persevere until it has been accomplished.

THE CHECK-OFF

The check-off is a provision in the agreement between the operators and the union whereby the former are obligated to deduct the union dues from the pay of the miners and turn it over to the union. Since the matter of collecting dues is the most vital point in maintaining the existence of any organization, the union officials have endeavored to make this a part of all their agreements with the operators. On the other hand the latter recognize the importance of this to the union and resent the measure keenly, feeling, no doubt, that it puts them in the uncomfortable position of nursing a viper in their breast.

The check-off has been one of the principal bones of contention in all the controversies between the operators and the miners since the beginning of unionism. The miners have succeeded in getting it generally established in most of the organized fields, the most important exception being the anthracite district. In that section they have worked out a very satisfactory substitute measure by furnishing the miners who have paid their dues with buttons; when any workman appears at the mine without his button, it is generally the signal for an immediate strike to force the management to discharge the man or require him to pay his dues.

The agreement covering the check-off applies only to union "dues" and there is considerable difference of opinion as to whether this can be interpreted as covering fines, special assessments, etc., that the local, district, or national organization may see fit to assess from time to time. Such assessments are sometimes levied by the national organization for the purpose of securing surplus funds in anticipation of a possible strike or to carry out a program for organizing a new field. A recent example of

these extra assessments was an increase in the dues to the national organization of from fifty cents to two dollars per month in November and December of 1922, presumably in anticipation of a strike the following April. When this was protested by some of the operators, the treasurers of the local organizations submitted assessments showing rather abnormal increases in other lines, such as for burial and sick funds, etc. A similar special assessment was levied in 1921, the obvious purpose of which was to finance an organization program that was being developed in the non-union fields of West Virginia; this the Pittsburgh district operators refused to collect and the matter was not pressed by the union.

The check-off is an institution peculiar to the coal industry, at least in so far as any of the other great basic industries are concerned. The amount collected under it is normally around $2 per month but may be anything above this and in some districts it has been at the rate of from $4 to $30 per month. In Pennsylvania it was $5 to $7 per month during 1923 and in the State of Washington it is reported to have amounted to as much as $43.80 per month. When the exigencies of the case demand, the miners' union is in a position to collect astonishingly large reserves, estimates of the assessments having amounted to as much as twenty million dollars in a single year. A defense fund of $875,000 is reported to have been raised for use in the Herrin massacre trials alone, and the establishment of the check-off in the anthracite district on the basis of an assessment of $7 per month would yield the union an estimated income of around thirteen million dollars annually.

There are no serious questions of civic rights or principles involved in the check-off as in some of the other great issues for which the union is contending. It has resolved

itself merely into a question of barter in which the strongest side will win. The commission appointed by President Roosevelt to settle the strike in 1903 did not allow the check-off nor did that appointed by President Wilson to settle the controversy of 1920. The union claims for it a power for disciplining its members and thus preventing unlawful strikes, etc., but in practice it appears to work the other way, as is evidenced by a number of strikes resulting from attempts of the operators to collect penalties from the miners. The public is concerned chiefly in the effect of the check-off on the cost of coal; as increasing assessments of the union are used as an argument for the need of increased wages, it would be expected that the check-off would have a tendency to increase the cost of coal.

STRENGTH OF THE UNION

In view of the powerful influence the United Mine Workers of America has in the coal industry it is of interest to consider what the actual strength of this organization is, both in point of numbers and the tonnage it controls. The exact strength of the union is something that no one can state positively outside of the inner circle of union officials. In some sections, such as Ohio, Indiana, and Illinois, the union has effected a one hundred per cent. organization which has stood the test of time and is loyal to the last man. Other districts that are generally recognized as union are less stable and in still others the balance of power swings first to one side and then the other and so through the scale down to the definitely unorganized fields. The extent of the unionization of many of the uncertain districts is also fluctuating from time to time, a sudden drive by either one side or the other changing the complexion of an entire district, sometimes over night.

The union claimed a membership of 445,734 at the end of 1923. Assuming the total number of workers in both the bituminous and anthracite fields to be 750,000, this would indicate that the country as a whole is sixty per cent. organized, but in the strike of 1919 the unions closed seventy-two per cent. of the production. These figures conform closely with the generally accepted estimate that one third of the production originates in the non-union fields. If we consider the bituminous field alone, however, and assume the anthracite district to be one hundred per cent. organized, the proportion is somewhat less. Thus deducting the one hundred and sixty thousand anthracite miners from both the total number of workers in the industry and from the number of union miners, we arrive at a figure of fifty per cent. as representing the proportion of union miners in the bituminous fields.

But it must not be assumed that a strike of all the union miners in the soft-coal fields will necessarily mean that the production of coal will be restricted by fifty per cent. It will be remembered, in this connection, that the productive capacity of all the mines in the country is fully fifty per cent. above the consumption. This overdevelopment of the mines is as characteristic of the non-union fields as it is of the union so that in an emergency we can reasonably expect the non-union mines to increase their production by fifty per cent., thus reducing the total deficiency in the supply to around twenty-five per cent. As a matter of fact conditions arise during a strike in the union mines that make it possible for the non-union operators to do something better than fifty per cent. above their normal output.

The cessation of all mining operations in the union districts, for instance, assures the non-union operators a bountiful car supply, thus eliminating delays from this

cause. Then, as the shortage becomes more evident, prices advance, stimulating additional activity on the part of the non-union operator and enabling him to increase his production by working overtime, Sundays, and holidays and by offering bonuses to the men for extra efforts. In addition to this the consumers always stock heavily whenever a strike is threatened, accumulating reserve supplies totaling in the neighborhood of sixty million tons, or better than ten per cent. of the annual consumption. It will thus be seen that while a stoppage at the union mines may create a general inconvenience and some high prices, there are sufficient reserve sources of supply available to eliminate the possibility of serious consequences. The principal disadvantage arising from a strike would be felt in the Eastern markets, which are more remote from most of the non-union territory and would consequently have the greatest difficulty in getting their supplies.

In the Eastern Appalachian field the union now has all of Ohio firmly organized and all of Pennsylvania except the following districts: Clearfield; Cambria; Somerset; Myersdale; Indiana; Latrobe; Connellsville; Youghiogheny; and Westmoreland. All of northern West Virginia is organized, except the Georges Creek and Potomac fields, and in the south the New River, Pocahontas, and Thacker fields are the only remaining strongholds of the non-union operators. Virginia is unorganized and only a small section of northern Kentucky has the union, all the balance of the Appalachian region through Kentucky, Tennessee, and Alabama being non-union. Practically all of the balance of the coal-producing sections in the country are more or less firmly unionized with the exception of Utah, New Mexico, and Colorado.

The mistake must not be made of belittling the financial

condition of the United Mine Workers of America, as it has resources that would rival those of a healthy corporation, even in these days of large aggregations of capital. During the two years and four months ending in November, 1923, the total income of the union from all sources was $8,747,000 and the balance on hand at the close of that year was $1,177,000. The organization is financially sound and responsible, as is evidenced by its capacity to borrow sums up to $150,000 from institutions like the Harriman National Bank of New York. In addition to this it always has available a quick source of supply for any funds it may require by making a special assessment on the miners, one levy of this description having brought in $1,760,000 in two months. The United Mine Workers of America is a big potential factor in the coal industry to-day and will be a continuing one in the future.

APPENDIX
OF
STATISTICAL TABLES

TABLE 1. ORIGINAL AND PRESENT QUANTITY OF COAL IN THE UNITED STATES, PRODUCTION OF THE MINES IN 1913 AND 1914, AND TOTAL PRODUCTION FROM THE BEGINNING OF COAL MINING TO THE PRESENT TIME, IN SHORT TONS — From U. S. Geological Survey

PROVINCE, REGION, OR FIELD	ESTIMATE OF THE ORIGINAL TONNAGE		PRODUCTION IN 1913	PRODUCTION IN 1914	TOTAL PRODUCTION TO END OF 1914	ESTIMATED SUPPLY WITHIN 3,000 FT. OF SURFACE
	Total Coal of all Ranks. Coal 0 to 3,000 Ft. Deep	Coal 3,000 to 6,000 Ft. Deep				
Eastern province:						
Anthracite region (Pennsylvania)	21,000,000,000	—	91,524,922	90,821,507	2,537,517,517	17,194,000,000
Atlantic coast region	900,000,000	—	—	—	477,125	799,000,000
Appalachian region	550,898,800,000	—	330,737,079	284,813,462	5,238,735,592	543,039,000,000
	572,798,800,000	—	422,262,001	375,634,969	7,776,730,234	561,032,000,000
Interior province:						
Northern and Eastern regions	321,990,800,000	—	88,533,841	83,412,955	1,439,863,711	319,830,000,000
Western and Southwestern regions	207,908,500,000	—	26,694,136	25,291,303	575,038,328	208,044,000,000
	529,899,300,000	—	115,227,977	108,704,258	2,014,902,039	527,874,000,000
Gulf province	23,090,000,000	—	1,181,156	1,105,613	10,509,960	23,074,000,000
Northern Great Plains province:						
Fort Union region, including Black Hills region	1,202,032,000,000	—	2,149,254	1,907,865	30,211,784	1,201,997,000,000
Small fields in Montana	9,073,400,000	—	1,904,355	1,561,823	24,907,259	9,036,000,000
Denver region and Canon City field	41,028,000,000	—	2,340,654	2,067,709	48,427,362	40,955,000,000
Raton Mesa region	42,392,000,000	—	8,194,362	7,596,810	133,390,905	42,192,000,000
	1,294,525,400,000	—	14,588,625	13,134,207	236,937,310	294,180,000,000

TABLE 1 (*continued*)

Province, Region, or Field	Estimate of the Original Tonnage		Production in 1913	Production in 1914	Total Production to end of 1914	Estimated Supply within 3,000 Ft. of Surface
	Total Coal of all Ranks. Coal 0 to 3,000 Ft. Deep	Coal 3,000 to 6,000 Ft. Deep				
Rocky Mountain province:						
Small fields in Montana	3,543,200,000	——	20,094	20,000	5,441,863	3,535,000,000
Bighorn Basin and Wind River Basin regions, including Red Lodge field	5,315,500,000	12,010,000,000	1,604,524	1,612,941	15,633,450	5,291,000,000
Green River and Hams Fork regions and Hanna field	665,660,600,000	396,720,000,000	5,786,093	5,377,756	101,339,390	665,478,000,000
Uinta region and Wasatch Plateau	168,248,400,000	243,540,000,000	4,092,435	3,723,542	57,317,183	167,682,000,000
North and South Parks	2,870,000,000	——	——	——	782,666	2,870,000,000
Southwestern Utah region	4,000,000,000	——	——	2,000	2,000	4,000,000,000
Coalville field, Utah	156,000,000	——	108,027	68,146	2,459,413	152,000,000
San Juan Basin region	196,036,000,000	14,330,000,000	1,007,729	874,332	17,573,377	196,011,000,000
Small fields in New Mexico and Arizona	21,896,000,000	——	117,976	137,361	4,148,414	21,890,000,000
Idaho and Nevada fields	700,000,000	——	——	——	——	700,000,000
	1,068,425,700,000	666,600,000,000	12,736,878	11,816,078	204,697,756	1,067,609,000,000
Pacific coast province:						
Washington fields	63,854,900,000	——	3,877,891	3,064,820	67,524,260	63,753,000,000
Oregon and California fields	1,043,000,000	——	*a*85,691	*a*65,532	*a*47,404,845	1,032,000,000
	64,897,900,000	——	3,963,582	3,130,352	114,929,105	64,785,000,000
	3,553,637,100,000	666,600,000,000	569,960,219	513,525,477	*b*10,357,706,404	3,538,554,000,000

a Includes production of Nevada and Idaho.
b A total production of 10,357,706,404 tons is assumed to mean an exhaustion of about 50 per cent more, or 15,083,100 tons.

TABLE 2. Coal Reserves of the Leading Countries. (Short Tons)

From U. S. Geological Survey

Country	Millions of Tons Add (000,000)
United States and Alaska	4,231,352
Canada	1,360,535
China	1,097,436
Germany (Year 1917)	466,665
Great Britain and Ireland	208,922
Siberia	191,667
Australia	182,510
India	87,083
Russia in Europe	66,255
Union of South Africa	61,949
Austria	59,387
Colombia	29,762
Indo-China	22,048
France (Year 1917)	19,382
Other countries	69,369
Total	8,154,322

TABLE 3. Relation of Population to Coal Reserves in the Leading Countries, in Metric Tons

Country	Population	Coal Reserves		Tons per Capita		
		A and B	Lignite	A & B	Lignite	Total
United States	105,000,000	2,000,000,000,000	1,800,000,000,000	19,000	17,000	36,000
Germany	65,000,000	410,000,000,000	13,400,000,000	6,300	200	6,500
United Kingdom	46,000,000	190,000,000,000	——	4,000	—	4,000
China	400,000,000	1,000,000,000,000	——	2,500	—	2,500
The world	1,500,000,000	4,500,000,000,000	3,000,000,000,000	3,000	2,000	5,000

A anthracite and B bituminous.

Note. — The reader is cautioned particularly to exercise great care in the use of all tables in this section to distinguish between the long (2,240 pounds), short (2,000 pounds) and metric (2,204.62 pounds) tons. The short ton is used almost exclusively in this country except in the anthracite regions of Pennsylvania and in the export and bunker trade where the long ton is commonly used. The metric ton is used largely abroad. For certain reasons that will be apparent it was impractical to reduce these to a uniform basis, and the reader must keep this before him in making comparisons between the different tables.

TABLE 4. Increase in Production of Three Chief Countries since 1875, in Millions of Metric Tons

	1875	1885	1895	1900	1910	1920
United States	48.2	102.2	177.6	243.4	445.8	597.2
Great Britain	135.5	162.0	194.3	228.8	264.5	233.2
Germany	48.5	73.7	104.0	150.0	222.0	252.4

TABLE 5. Coal Production of Five Chief Coal Mining Countries for Years 1911 to 1923 in Short Tons

From U. S. Geological Survey

Year	United States Tons	% of Total	Great Britain	France	Belgium	Prussia	World Production
1911	496,371,126	37.9	320,255,300	43,242,778	25,411,917	167,021,463	1,307,900,000
1912	534,466,580	38.8	305,975,041	45,354,330	25,322,190	182,415,297	1,373,900,000
1913	569,960,219	38.6	337,804,715	45,022,582	25,178,285	198,477,571	1,476,200,000
1914	513,525,477	38.7	312,575,730	30,344,235	18,423,897	168,796,999	1,327,700,000
1915	531,619,487	40.6	296,236,935	21,531,151	15,627,858	154,512,173	1,307,900,000
1916	590,098,175	42.7	299,110,504	23,490,093	18,587,942	168,048,180	1,382,700,000
1917	651,402,374	44.6	291,334,466	31,873,453	16,445,985	176,058,489	1,457,500,000
1918	678,211,904	46.4	267,587,603	28,945,387	15,240,102	168,641,052	1,464,100,000
1919	553,952,259	43.1	268,353,052	24,737,133	20,219,434	123,665,769	1,284,800,000
1920	658,264,932	45.3	268,393,080	——	24,679,141	140,217,837	1,450,900,000
1921	506,395,401	40.4	188,207,655	——	23,975,477	——	1,249,600,000
1922	476,951,121	34.6	286,688,300	——	23,378,130	——	1,328,800,000
1923*b*	641,476,000						

b Estimated.

TABLE 6. Coal Reserves by Continents. (Short Tons)

From U. S. Geological Survey

Americas	5,627,823,500,000
Asia	1,410,487,600,000
Europe	864,412,600,000
Oceania	187,842,900,000
Africa	63,755,900,000
Total	8,154,322,500,000

TABLE 7. Coal Produced in the Principal Countries of the World in the Calendar Years 1920, 1921, and 1922

(In metric tons of 2,204.6 lbs.)

Country	1920	1921	1922
North America			
Canada: Coal	12,020,531	10,684,259	10,561,140
Lignite	3,353,234	2,975,598	3,087,642
Greenland	2,308	2,200	(a)
Mexico	(a)	(a)	(a)
United States: Anthracite	81,282,000	82,076,000	47,613,000
Bituminous and lignite	515,883,000	377,316,000	370,033,000
South America			
Argentina	(a)	(a)	(a)
Brazil	(a)	(a)	(a)
Chile	1,063,185	1,275,117	1,046,378
Colombia	(a)	(a)	(a)
Peru	631,075	345,481	(a)
Venezuela	30,377	(a)	(a)
Europe			
Austria: Coal	132,864	137,633	166,540
Lignite	2,408,865	2,478,862	3,109,926
Belgium	22,388,770	21,750,410	21,234,170
Bulgaria	757,250	911,664	985,640
Czechoslovakia: Coal	11,143,221	11,648,399	9,906,261
Lignite	19,943,258	21,050,712	18,942,920
France: Coal	24,293,000	28,243,000	31,157,984
Lignite	967,800	735,600	757,633
Germany: Coal *b*	140,766,397	145,610,000	*c*141,204,600
Lignite	111,887,694	123,011,000	137,207,125
Greece	197,454	134,000	(a)
Hungary	4,963,060	6,418,560	7,117,910
Italy: Coal	151,862	114,236	197,920
Lignite	1,571,735	1,026,035	704,600
Netherlands: Coal	4,115,629	4,243,000	4,475,000
Lignite	1,395,851	121,715	0
Poland	6,660,145	7,842,553	*d*23,800,000
Portugal	169,165	135,732	(a)
Rumania	1,570,393	1,791,224	(a)
Russia	6,137,000	9,851,000	*e*10,000,000
Spain: Coal	5,420,704	5,012,229	(a)
Lignite	552,425	408,674	(a)
Spitsbergen	130,000	210,000	316,000
Sweden	439,584	376,692	(a)
Switzerland	74,590	10,714	(a)
United Kingdom:			
Great Britain	233,106,377	165,781,404	255,891,786
Ireland	109,845	89,958	(a)
Yugoslavia	3,412,361	2,949,103	(a)
Asia			
British India	18,250,508	19,511,154	19,000,000
China	19,484,896	19,876,375	21,300,000
Chosen	293,675	(a)	(a)
Federated Malay States	251,896	304,156	(a)
Indo China	700,267	920,900	1,000,000
Japan (including Taiwan and Karafuto) *f*	30,550,625	27,418,000	26,000,000
Russia	1,537,000	2,384,100	*e*2,000,000
Turkey	*e*700,000	(a)	(a)
Africa			
Algeria	7,793	9,541	8,855
Belgian Congo	2,000	2,990	(a)
Nigeria	183,013	216,262	112,563
Rhodesia, Southern	524,796	521,404	467,787
Tunis	31,331	22,207	270
Union of South Africa	10,408,497	10,339,044	8,822,760
Oceanica			
Australia:			
New South Wales	10,887,991	10,966,621	10,346,572
Queensland	1,127,727	970,087	1,100,000
Tasmania	76,640	67,543	70,000
Victoria	614,632	603,618	600,000
Western Australia	469,436	476,341	450,000
British Borneo	(a)	(a)	(a)
Dutch East Indies	1,095,718	1,212,665	(a)
New Zealand	1,873,296	1,838,131	(a)
Philippine Islands	58,888	(a)	(a)
Total	1,319,100,000	1,136,000,000	1,208,000,000

(*a*) Estimate included in total. (*b*) Includes the Saar. (*c*) Includes entire output of Upper Silesia for January–May, for June–December only that part of Upper Silesia allocated to Germany. (*d*) Includes for June–December that part of Upper Silesia awarded to Poland. (*e*) Estimated on incomplete data. (*f*) Exclusive of lignite from Japan (annual production of about 200,000 tons), for which estimate is included in total.

TABLE 8. COAL PRODUCED IN THE UNITED STATES SINCE THE BEGINNING OF MINING, IN SHORT TONS

From the U. S. Geological Survey

YEAR	PENNSYLVANIA ANTHRACITE	BITUMINOUS	TOTAL	YEAR	PENNSYLVANIA ANTHRACITE	BITUMINOUS	TOTAL
1807–1820	12,000	3,000	15,000	1871	19,342,057	27,543,023	46,885,080
				1872	24,233,166	27,220,233	51,453,399
1821	1,322	——	1,322	1873	26,152,837	31,449,643	57,602,480
1822	4,583	54,000	58,583	1874	24,818,790	27,787,130	52,605,920
1823	8,563	60,000	68,563	1875	22,485,766	29,862,554	52,348,320
1824	13,685	67,040	80,725				
1825	42,988	75,000	117,988	1876	22,793,245	30,486,755	53,280,000
				1877	25,660,316	34,841,444	60,501,760
1826	59,194	88,720	147,914	1878	21,689,682	36,245,918	57,935,600
1827	78,151	94,000	172,151	1879	30,207,793	37,898,006	68,105,799
1828	95,500	100,408	195,908	1880	28,649,812	42,831,758	71,481,570
1829	138,086	102,000	240,086				
1830	215,272	104,800	320,072	1881	31,920,018	53,961,012	85,881,030
				1882	35,121,256	68,429,933	103,551,189
1831	217,842	120,100	337,942	1883	38,456,845	77,250,680	115,707,525
1832	447,550	146,500	594,050	1884	37,156,847	82,998,704	120,155,551
1833	600,907	133,750	734,657	1885	38,335,974	72,824,321	111,160,295
1834	464,015	136,500	600,515				
1835	690,854	134,000	824,854	1886	39,035,446	74,644,981	113,680,427
				1887	42,088,197	88,562,314	130,650,511
1836	842,832	142,000	984,832	1888	46,619,564	102,040,093	148,659,657
1837	1,071,151	182,500	1,253,651	1889	45,546,970	95,682,543	141,229,513
1838	910,075	445,452	1,355,527	1890	46,468,641	111,302,322	157,770,963
1839	1,008,322	552,038	1,560,360				
1840	967,108	1,102,931	2,070,039	1891	50,665,431	117,901,238	168,566,669
				1892	52,472,504	126,856,567	179,329,071
1841	1,182,441	1,108,700	2,291,141	1893	53,967,543	128,385,231	182,352,774
1842	1,365,563	1,244,494	2,610,057	1894	51,921,121	118,820,405	170,741,526
1843	1,556,753	1,504,121	3,060,874	1895	57,999,337	135,118,193	193,117,530
1844	2,009,207	1,672,045	3,681,252				
1845	2,480,032	1,829,872	4,309,904	1896	54,346,081	137,640,276	191,986,357
				1897	52,611,680	147,617,519	200,229,199
1846	2,887,815	1,977,707	4,865,522	1898	53,382,644	166,593,623	219,976,267
1847	3,551,005	1,735,062	5,286,067	1899	60,418,005	193,323,187	253,741,192
1848	3,805,942	1,968,032	5,773,974	1900	57,367,915	212,316,112	269,684,027
1849	3,995,334	2,453,497	6,448,831				
1850	4,138,164	2,880,017	7,018,181	1901	67,471,667	225,828,149	293,299,816
				1902	41,373,595	260,216,844	301,590,439
1851	5,481,065	3,253,460	8,734,525	1903	74,607,068	282,749,348	357,356,416
1852	6,151,957	3,664,707	9,816,664	1904	73,156,709	278,659,689	351,816,398
1853	6,400,426	4,169,862	10,570,288	1905	77,659,850	315,062,785	392,722,635
1854	7,394,875	4,582,227	11,977,102				
1855	8,141,754	4,784,919	12,926,673	1906	71,282,411	342,874,867	414,157,278
				1907	85,604,312	394,759,112	480,363,424
1856	8,534,779	5,012,146	13,546,925	1908	83,268,754	332,573,944	415,842,698
1857	8,186,567	5,153,622	13,340,189	1909	81,070,359	379,744,257	460,814,616
1858	8,426,102	5,548,376	13,974,478	1910	84,485,236	417,111,142	501,596,378
1859	9,619,771	6,013,404	15,633,175				
1860	8,115,842	6,494,200	14,610,042	1911	90,464,067	405,907,059	496,371,126
				1912	84,361,598	450,104,982	534,466,580
1861	9,799,654	6,688,358	16,488,012	1913	91,524,922	478,435,297	569,960,219
1862	9,695,110	7,790,725	17,485,835	1914	90,821,507	422,703,970	513,525,477
1863	11,785,320	9,533,742	21,319,062	1915	88,995,061	442,624,426	531,619,487
1864	12,538,649	11,066,474	23,605,123				
1865	11,891,746	11,900,427	23,792,173	1916	87,578,493	502,519,682	590,098,175
				1917	99,611,811	551,790,563	651,402,374
1866	15,651,183	13,352,400	29,003,583	1918	98,826,084	579,385,820	678,211,904
1867	16,002,109	14,722,313	30,724,422	1919	88,092,201	465,860,058	553,952,259
1868	17,003,405	15,858,555	32,861,960	1920	89,598,249	568,666,683	658,264,932
1869	17,083,134	15,821,226	32,904,360				
1870	15,664,275	17,371,305	33,035,580	1921	90,473,451	415,921,950	506,395,401
				1922 [1]	52,465,000	422,000,000	474,465,000
				1923 [1]	95,000,000	545,000,000	640,000,000
					3,328,157,867	12,313,937,079	15,642,094,946

[1] Estimated.

TABLE 8–A. Production of Coal by the States in Net or Short Tons during the Years 1912 to 1921.[a]

State	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	Total 10 Years
Alabama	16,100,600	17,678,522	15,593,422	14,977,937	18,086,197	20,068,074	19,184,962	15,536,721	16,294,099	12,568,899	166,039,433
Alaska	355	2,300	(*b*)	1,400	13,073	53,955	75,606	60,674	61,111	76,817	345,291
Arkansas	2,100,819	2,234,107	1,836,540	1,652,106	1,994,915	2,143,579	2,227,369	1,429,020	2,103,596	1,227,777	18,949,828
California, Idaho, and Nevada	13,942	26,788	13,974	12,503	7,240	6,423	6,400	6,554	2,753	c38,845	135,422
Colorado	10,977,824	9,232,510	8,170,559	8,624,980	10,484,237	12,483,336	12,407,571	10,323,420	12,278,225	9,122,760	104,105,422
Georgia and North Carolina	227,703	255,626	166,498	134,496	173,554	119,028	68,136	60,326	61,696	57,253	1,324,316
Illinois	59,885,226	61,618,744	57,589,197	58,829,576	66,195,336	86,199,387	89,291,105	60,862,608	88,724,893	69,602,763	698,798,835
Indiana	15,285,718	17,165,671	16,641,132	17,006,152	20,093,528	26,539,329	30,678,634	20,912,288	29,350,585	20,319,509	213,992,546
Iowa	7,289,529	7,525,936	7,451,022	7,614,143	7,260,800	8,965,830	8,192,195	5,624,692	7,813,916	4,531,392	72,269,455
Kansas	6,986,182	7,202,210	6,860,988	6,824,474	6,881,455	7,184,975	7,561,947	5,224,724	5,926,408	3,466,641	64,120,004
Kentucky	16,490,521	19,616,600	20,382,763	21,361,674	25,393,997	27,807,971	31,612,617	30,036,061	35,690,762	31,588,270	259,981,236
Maryland	4,964,038	4,779,839	4,133,547	4,180,477	4,460,046	4,745,924	4,497,297	3,021,686	4,065,239	1,827,740	40,675,833
Michigan	1,206,230	1,231,786	1,283,030	1,156,138	1,180,360	1,374,805	1,464,818	996,545	1,489,765	1,141,715	12,525,192
Missouri	4,339,856	4,318,125	3,935,980	3,811,593	4,742,146	5,670,549	5,667,730	3,979,798	5,369,565	3,551,621	45,386,963
Montana	3,048,495	3,240,973	2,805,173	2,789,755	3,632,527	4,226,689	4,532,505	3,236,369	4,413,866	2,733,958	34,660,310
New Mexico	3,536,824	3,708,806	3,877,689	3,817,940	3,793,011	4,000,527	4,023,239	3,138,756	3,683,440	2,453,482	36,033,714
North Dakota	499,480	495,320	506,685	528,078	634,912	790,548	719,733	840,959	948,625	864,903	6,829,243
Ohio	34,528,727	36,200,527	18,843,115	22,434,691	34,728,219	40,748,734	45,812,943	35,876,682	45,878,191	31,942,776	346,994,605
Oklahoma	3,675,418	4,165,770	3,988,613	3,693,580	3,608,011	4,386,844	4,813,447	3,802,113	4,849,288	3,362,623	40,345,707
Oregon	41,637	46,063	51,558	39,231	42,592	28,327	13,328	18,739	20,717	(*d*)	302,192
Pennsylvania (bituminous)	161,865,488	173,781,217	147,983,294	157,955,137	170,295,424	172,448,142	178,550,741	150,758,154	170,607,847	116,013,942	1,600,259,386
South Dakota	———	———	11,850	10,593	8,886	8,042	7,942	14,417	12,777	7,553	82,060
Tennessee	6,473,228	6,903,784	5,943,258	5,730,361	6,137,449	6,194,221	6,831,048	5,213,205	6,662,428	4,460,326	60,549,308
Texas	2,188,612	2,429,144	2,323,773	2,088,908	1,987,503	2,355,815	2,261,135	1,680,656	1,615,015	972,839	19,903,400
Utah	3,016,149	3,254,828	3,103,036	3,108,715	3,567,428	4,125,230	5,136,825	4,631,323	6,005,199	4,078,784	40,027,517
Virginia	7,846,638	8,828,068	7,959,535	8,122,596	9,707,474	10,087,091	10,289,808	9,326,830	11,378,606	7,492,378	91,039,024
Washington	3,360,932	3,877,891	3,064,820	2,429,095	3,038,588	4,009,902	4,082,212	2,990,447	3,757,093	2,428,722	33,039,702
West Virginia	66,786,687	71,308,982	71,707,626	77,184,069	86,460,127	86,441,667	89,935,839	79,036,553	89,970,707	72,786,996	791,619,253
Wyoming	7,368,124	7,393,066	6,475,293	6,554,028	7,910,647	8,575,619	9,438,688	7,219,738	9,630,271	7,200,666	77,766,140
Total (bituminous)	**450,104,982**	**478,523,203**	**422,703,970**	**442,624,426**	**502,519,682**	**551,790,563**	**579,385,820**	**465,860,058**	**568,666,683**	**415,921,950**	**4,878,101,337**
Pennsylvania (anthracite)	84,361,598	91,524,922	90,821,507	88,995,061	87,578,493	99,611,811	98,826,084	88,092,201	89,598,249	90,473,451	909,883,377
Total	**534,466,580**	**570,048,125**	**513,525,477**	**531,619,487**	**590,098,175**	**651,402,374**	**678,211,904**	**553,952,259**	**658,264,932**	**506,395,401**	**5,787,984,714**

a Compiled from Mineral Resources, U. S. Geological Survey.
b Not available.
c Includes Oregon.
d Included with California, Idaho, and Nevada.

TABLE 9. List of Major Coal Mine Disasters in the United States since the Beginning of Mining

The accompanying table, compiled from reports of the U. S. Bureau of Mines, gives a list of all of the coal mine disasters involving 100 or more lives in the United States down to and including 1923 with additional particulars for that year and major disasters in the first of 1924.

Date	Name of Mine	Location of Mine	Nature of Disaster	Killed
1869 Sept. 6	Avondale	Plymouth, Pa.	Mine fire	179
1884 Mar. 13	Laurel	Pocahontas, Va.	Explosion	112
1891 Jan. 27	Mammouth	Mt. Pleasant, Pa.	Gas explosion	109
1892 Jan. 7	No. 11	Krebs, Okla.	Explosion	100
1900 May 1	Winterquarters Nos. 1 and 4	Scofield, Utah	Coal-dust explosion	200
1902 May 19	Fraterville	Coal Creek, Tenn.	do	184
1902 July 10	Rolling Mill	Johnstown, Pa.	Gas explosion	112
1903 June 30	Hanna No. 1	Hanna, Wyo.	Explosion and fire	169
1904 Jan. 25	Harwick	Cheswick, Pa.	Coal-dust explosion	179
1905 Feb. 20	Virginia City	Virginia City, Ala.	do	108
1907 Dec. 6	Monongah Nos. 6 and 8	Monongah, W. Va.	do	361
1907 Dec. 19	Darr	Jacobs Creek, Pa.	do	239
1908 Nov. 28	Rachel and Agnes Mines	Marianna, Pa.	do	154
1909 Nov. 13	St. Paul No. 2	Cherry, Ill.	Mine fire	259
1911 Apr. 8	Banner Mine	Littleton, Ala.	Coal-dust explosion	128
1913 Oct. 22	Stag Canon No. 2	Dawson, N. Mex.	do	263
1914 Apr. 28	Eccles Nos. 5 and 6	Eccles, W. Va.	Gas explosion	181
1915 Mar. 2	Layland No. 3	Layland, W. Va.	Coal-dust explosion	112
1917 Apr. 27	Hastings Mine	Hastings, Colo.	do	121
1923 Jan. 10	Dolomite No. 1	Dolomite, Ala.	Gas explosion	5
1923 Feb. 8	Dawson No. 1	Dawson, N. M.	Dust explosion	120
1923 Feb. 21	Alliance	Schuylkill, Pa.	Gas explosion	5
1923 Mar. 2	Arista	Arista, W. Va.	Dust explosion	10
1923 May 5	Southwestern	Aguilar, Colo.	Gas explosion	10
1923 June 26	Richards Colliery	Northumberland County, Pa.	do	5
1923 Aug. 14	Frontier No. 1	Kemmerer, Wyo.	do	99
1923 Oct. 7	Midwest	Mesa Co., Colo.	do	6
1923 Nov. 6	Glen Rogers	Beckley, W. Va.	do	27
1923 Dec. 7	Happy	Happy, Perry Co., Ky.	Dust explosion	9
1923 Dec. 8	Mount Jessup No. 2	Jessup, Pa.	Fall of roof	5
1924 Mar. 8	Utah Fuel Co. No. 2	Castlegate, Utah	Coal-dust explosion	173
1924 Apr. 28	Wheeling Steel Corporation	Benwood, W. Va.	Gas explosion	116

TABLE 10. Fatality Rates in the Coal Mines of the United States for the Years 1907 to 1922

From U. S. Bureau of Mines

Year	Men Employed		Average Days Active	Total Shifts	Men Killed	Killed per 1,000 300-Day Workers	Production (Short Tons)	Production per Death (Short Tons)	Average Production per Man	
	Actual Number	Equivalent in 300-Day Workers							Tons per Year	Tons per Day
1907*a*	674,613	519,452	231	155,835,603	3,242	6.24	477,892,536	147,407	708	3.07
1908*a*	678,873	441,267	195	132,380,235	2,445	5.54	409,309,857	167,407	603	3.09
1909*a*	666,535	——	—	——	2,642	—	460,807,263	174,416	691	—
1910	725,030	531,689	220	159,506,600	2,821	5.31	501,596,378	177,808	692	3.14
1911	728,348	534,122	220	160,236,560	2,656	4.97	496,371,126	186,887	682	3.10
1912	722,662	541,997	225	162,598,950	2,419	4.46	534,466,580	220,945	740	3.29
1913	747,644	593,131	238	177,939,272	2,785	4.70	570,048,125	204,685	762	3.20
1914	763,185	526,598	207	157,979,295	2,454	4.66	513,525,477	209,261	673	3.25
1915	734,008	511,598	209	153,479,495	2,269	4.44	531,619,487	234,297	724	3.46
1916	720,971	565,766	235	169,729,816	2,226	3.93	590,098,175	265,094	818	3.48
1917	757,317	634,666	251	190,399,680	2,696	4.25	651,402,374	241,618	860	3.42
1918	762,426	654,973	258	196,491,984	2,580	3.94	678,211,904	262,873	890	3.45
1919	776,569	542,217	209	162,665,023	2,317	4.27	553,952,259	239,082	713	3.41
1920	784,621	601,283	230	180,384,942	2,271	3.78	658,264,932	289,857	839	3.65
1921	823,253	474,529	173	142,358,691	1,987	4.19	506,395,401	254,854	615	3.56
1922*b*	848,932	——	—	——	1,971		460,379 000	233,576	—	—

a Figures are only for States under inspection service. Figures omitted for 1909 (census year) because not comparable.

b Number of employees based on estimates of State mine inspectors.

TABLE 11. MINE FATALITIES BY CAUSES IN THE UNITED STATES FOR THE YEARS 1916 TO 1921

From U. S. Bureau of Mines

INSIDE	1916	1917	1918	1919	1920	1921
Falls of roof (coal, rock, etc.)	962	1,057	1,182	946	1,004	924
Falls of face or pillar coal	103	173	112	154	128	100
Mine cars and locomotives	390	488	506	381	408	341
Gas explosions and burning gas	170	197	95	144	130	96
Dust explosion, including dust and gas explosions	56	163	34	47	34	20
Explosives	146	110	135	206	128	152
Suffocation from mine gases	12	8	15	11	18	9
Electricity	90	79	88	69	76	80
Animals	8	9	8	2	4	7
Mining machines (other than electricity as given above)	20	19	17	26	37	18
Mines fires (burned, suffocated, etc.)	3	2	26	22	8	9
Other causes	67	70	63	69	45	75
Total, inside	2,027	2,375	2,281	2,077	2,020	1,831
KILLED IN SHAFTS						
Falling down shafts or slopes	31	21	21	20	27	18
Objects falling down shafts or slopes	2	12	9	6	8	9
Cage, skip, or bucket	12	22	17	21	19	9
Total in shafts	49	60	52	53	56	36
OUTSIDE						
Mine cars and mine locomotives	59	74	87	71	54	25
Electricity	7	17	15	10	17	17
Machinery	22	46	40	22	25	16
Boiler explosions and steam pipes	4	8	7	6	4	1
Railway cars and locomotives	16	36	31	22	24	20
Other causes	42	80	67	56	71	41
Total outside	150	261	247	187	195	120
Grand total	2,226	2,696	2,580	2,317	2,271	1,987

TABLE 12. Bituminous Coal Mined by Machines in the United States, 1891–1921

From U. S. Geological Survey

Year	Machines in Use	Quantity Mined by Machine (Net Tons)		Year	Machines in Use	Quantity Mined by Machine (Net Tons)	
		Total	Average per Machine			Total	Average per Machine
1891	545	6,211,732	11,398	1909	13,049	142,496,878	10,920
1896	1,446	16,424,932	11,373	1910	13,254	174,012,293	13,127
1897	1,956	22,649,220	11,579	1911	13,829	178,158,236	12,854
1898	2,622	32,413,144	12,362	1912	15,298	210,538,822	13,763
1899	3,125	43,963,933	14,068	1913	16,379	242,421,713	14,801
1900	3,907	52,784,523	13,510	1914	16,507	218,399,287	13,231
1901	4,341	57,843,335	13,325	1915	15,692	243,237,551	15,501
1902	5,418	69,611,582	12,848	1916	16,198	283,691,475	17,514
1903	6,658	77,974,894	11,712	1917	17,235	306,396,127	17,777
1904	7,663	78,606,997	10,258	1918	18,463	323,931,133	17,545
1905	9,184	103,396,452	11,258	1919	18,959	276,019,799	14,559
1906	10,212	118,847,527	11,638	1920	19,103	339,813,476	17,788
1907	11,144	138,547,823	12,432	1921	19,618	272,702,389	13,901
1908	11,569	123,183,334	10,648				

Anthracite (Pennsylvania) Mined by Machines, 1916–1921

Year	Gross Tons	Year	Gross Tons
1916	1,642,416	1919	1,406,433
1917	1,745,735	1920	837,565
1918	1,658,495	1921	874,237

TABLE 13. ANALYSES OF REPRESENTATIVE AMERICAN COALS

The following table gives the analyses of representative American coals, from a selected list of typical analyses of the U. S. Geological Survey. Nearly all of the analyses were made by either the Survey or the Bureau of Mines, the methods of which are identical, so that they may be accepted as comparable. They are all of samples as taken in the mine and therefore show a somewhat higher moisture content than the usual commercial sample. Abbreviations used for designating the different kinds of coal are:

A	Anthracite	SuB	Subbituminous
B	Bituminous	SeA	Semianthracite
C	Coking coal	SeB	Semibituminous (Super-coals)
L	Lignite		

DISTRICT	GRADE	MOISTURE	VOLATILE MATTER	FIXED CARBON	ASH	SULPHUR	B. T. U.
ALABAMA							
Lookout Mountain	SeB	3.8	19.0	64.4	12.8	1.5	12,980
Birmingham District	C	2.4	25.9	66.8	4.9	1.5	14,490
Birmingham District	B	2.6	31.8	62.9	2.7	0.8	14,630
Carbon Hill District	B	4.7	31.8	53.3	10.2	1.3	12,600
Tuscaloosa District	B	1.6	25.0	68.5	4.9	0.5	14,700
Cahaba Field	B	3.1	35.0	55.8	6.1	0.4	13,560
ARKANSAS							
Spadra District	SeA	1.7	10.5	79.5	8.3	2.5	13,870
Jenny Lind District	SeB	1.6	17.4	73.1	7.9	1.4	14,160
Camden District	L	39.4	26.5	24.4	9.7	0.5	6,360
COLORADO							
Colorado Springs Field	SuB	26.2	29.7	37.7	6.4	0.3	8,350
Canon City Field	B	9.1	35.7	48.0	7.2	0.9	11,700
Trinidad Field	C	2.3	29.8	58.7	9.2	0.5	13,780
North Park Field	SuB	20.0	32.5	42.5	5.0	0.6	9,750
Yampa Field	B	10.4	37.9	45.5	6.2	0.4	11,470
Newcastle Field	C	2.9	33.3	56.7	7.1	0.5	13,720
Coal Basin Field	SeB	2.4	19.4	70.8	7.4	0.5	14,380
Crested Butte Field	B	5.6	37.5	47.6	9.2	0.4	12,430
Grand Junction Field	B	7.5	33.6	52.9	5.9	0.7	12,440
Durango Field	C	2.7	36.1	54.5	6.7	0.5	13,910
ILLINOIS							
La Salle County	B	13.9	37.3	38.5	10.3	3.4	10,990
Fulton County	B	15.7	31.4	43.1	9.8	3.0	10,620
Macoupin County	B	13.3	37.1	40.7	8.9	4.1	11,160
Madison and St. Clair Counties	B	12.7	36.4	41.4	9.5	3.7	10,990
Franklin County	B	9.2	33.8	48.6	8.4	0.9	11,930
Williamson County	B	8.8	29.9	53.8	7.5	1.1	12,220
Saline County	B	6.0	32.4	54.3	7.3	1.7	12,790
Gallatin County	B	3.4	35.2	52.5	8.9	2.9	13,190

TABLE 13 (*Continued*)

District	Grade	Moisture	Volatile Matter	Fixed Carbon	Ash	Sulphur	B.T.U.
INDIANA							
Clay County	B	15.4	32.6	46.1	5.9	2.0	11,680
Sullivan County	B	13.6	35.0	44.6	6.8	1.1	11,550
Knox County	B	10.6	38.1	43.0	8.3	3.7	11,750
IOWA							
Polk County	B	14.4	37.8	36.8	11.0	5.9	10,640
Marion County	B	15.7	36.9	35.8	11.6	5.1	10,290
Lucas County	B	18.7	31.8	41.8	7.7	2.4	10,510
Wapello County	B	11.3	38.7	39.5	10.5	4.7	11,350
KANSAS							
Leavenworth County	B	12.0	35.2	39.1	13.7	4.4	10,720
Crawford County	B	4.9	33.5	52.5	9.1	5.0	12,940
EASTERN KENTUCKY							
Johnson County	B	6.4	36.2	54.1	3.3	1.2	13,460
Pike County	B	2.8	36.2	56.7	4.3	1.4	14,180
Perry County	B	3.9	37.2	54.8	4.1	0.8	13,730
Harlan County	B	4.4	35.0	56.9	3.7	0.7	13,920
Bell County	B	2.8	37.8	56.3	3.1	1.0	14,240
Knox County	B	4.2	36.4	53.3	6.1	0.8	13,410
WESTERN KENTUCKY							
Daviess County	B	11.8	36.8	42.0	9.4	3.3	11,150
Ohio County	B	10.0	36.5	44.9	8.6	2.6	11,770
Hopkins County	B	8.5	38.0	46.4	7.1	3.5	12,340
MARYLAND [1]							
Georges Creek Basin	SeB	0.6	16.6	72.1	10.7	1.3	13,380
Georges Creek Basin	SeB	0.6	17.7	73.0	8.7	1.4	14,010
Upper Potomac Basin	SeB	0.9	18.1	71.9	9.1	1.7	14,010
Castleman Basin	SeB	2.1	22.0	67.1	8.8	2.3	13,870
Upper Youghiogheny Basin	B	1.2	23.0	63.9	11.9	2.1	13,260
MICHIGAN							
Saginaw District	B	11.9	31.5	49.8	6.8	1.2	11,780

[1] These analyses were made by the Maryland Geological Survey and each one is the average of a large number of analyses of each bed or field.

TABLE 13 (*Continued*)

District	Grade	Moisture	Volatile Matter	Fixed Carbon	Ash	Sulphur	B. T. U.
Missouri							
Putnam County	B	18.5	32.6	39.0	9.9	4.1	10,040
Macon County	B	13.8	34.7	41.8	9.7	3.3	10,960
Lafayette County	B	12.3	34.4	42.0	11.3	4.6	11,000
Barton County	B	5.4	32.1	53.6	8.9	3.6	12,990
Montana							
Sand Coulee District	B	6.0	28.4	51.4	14.2	2.4	11,150
Roundup District	SuB	13.4	32.4	47.6	6.6	0.4	11,120
Bridger District	B	9.8	27.6	46.2	16.4	0.6	10,240
Bear Creek District	SuB	10.7	34.1	46.1	9.1	1.5	10,800
Red Lodge District	SuB	11.7	36.1	40.2	12.0	1.1	9,790
Trail Creek Field	B	12.4	36.8	42.3	8.5	0.6	10,950
New Mexico							
Raton Field	C	2.1	36.1	50.2	11.6	0.6	12,970
Los Cerrillos Field	B	3.2	41.4	44.4	11.0	1.6	12,450
Carthage Field	C	3.0	38.0	51.6	7.4	0.9	13,260
Gallup District	SuB	12.7	36.5	43.3	7.5	0.7	11,230
North Dakota							
Williams County	L	41.1	27.2	26.3	5.4	0.7	6,490
Southern McLean County	L	40.5	27.1	27.4	5.0	0.8	6,640
Adams County	L	32.4	30.9	28.1	8.6	1.5	7,330
Ohio							
Tuscarawas County	B	4.7	39.2	49.9	6.2	3.3	12,770
Jefferson County	B	4.1	38.5	49.7	7.7	3.7	13,150
Belmont County	B	3.9	43.1	43.9	9.1	4.4	12,840
Guernsey County	B	6.0	34.2	52.0	7.8	2.0	12,720
Noble County	B	3.6	41.5	44.4	10.5	4.9	12,510
Perry County	B	6.7	37.1	49.1	7.1	2.6	12,390
Hocking County	B	7.5	34.0	52.6	5.9	0.8	12,510
Meigs County	B	7.2	32.8	50.7	9.3	1.3	12,000
Jackson County	B	5.3	41.0	45.3	8.4	3.7	12,210
Oklahoma							
Tulsa County	B	6.3	37.7	47.8	8.2	8.2	12,690
Haskell County	SeB	2.7	21.1	69.9	6.3	0.8	14,100
Pittsburgh County	B	3.6	33.4	58.0	5.0	0.5	13,740
Coal County	B	6.5	39.0	45.2	9.3	3.7	11,840

TABLE 13 (*Continued*)

District	Grade	Moisture	Volatile Matter	Fixed Carbon	Ash	Sulphur	B. T. U.
Pennsylvania							
Anthracite Regions	A	2.8	1.2	88.2	7.8	0.9	13,300
Sullivan County	SeA	3.4	9.3	75.6	11.7	0.8	13,120
Tioga County	SeB	2.3	20.9	66.9	9.9	1.3	13,620
Center County	SeB	2.9	19.9	69.7	7.5	1.9	14,080
Clearfield County	SeB	3.3	19.9	69.0	7.8	2.0	14,020
Clearfield County	B	2.8	24.3	66.3	6.6	0.9	14,130
Indiana County	B	1.0	26.1	63.8	9.1	2.7	13,950
Butler County	B	4.6	33.0	54.4	8.0	1.3	13,200
Cambria County	SeB	3.3	12.5	77.9	6.3	1.0	14,340
Cambria County	B	3.1	26.0	64.4	6.5	1.4	14,160
Westmoreland County	C	2.7	30.4	57.8	9.1	1.3	13,610
Allegheny County	B	3.7	34.0	56.8	5.5	1.4	13,870
Broadtop Field	SeB	2.1	15.5	76.0	6.4	1.1	14,470
Somerset County	SeB	2.5	12.5	78.8	6.2	1.1	14,380
Somerset County	SeB	2.6	21.5	68.0	7.9	1.7	13,900
Fayette County	C	2.8	30.0	59.8	7.4	1.2	13,990
Washington County	B	1.4	34.6	57.8	6.2	0.8	14,240
Tennessee							
Scott and Fentress Counties	B	3.8	38.5	51.2	6.5	1.9	13,400
Morgan County	B	2.0	37.5	52.6	7.9	4.0	13,810
Cumberland County	B	4.3	25.7	62.5	7.5	0.6	13,630
Bledsoe and Sequatchie Counties	B	3.0	29.8	58.9	8.3	1.0	13,560
Texas							
Houston County	L	33.5	39.5	16.2	10.8	0.6	7,140
Wood County	L	28.9	35.9	27.3	7.9	0.5	8,000
Utah							
Uinta County	B	8.6	36.1	47.2	8.1	1.4	11,580
Grand County	B	7.1	37.0	45.4	10.5	0.7	11,720
Carbon County	B	4.4	38.2	50.5	6.9	0.8	12,760
Iron and Kane Counties	B	10.4	36.3	43.7	9.6	5.8	10,870
Virginia							
Tazewell County	SeB	3.8	15.5	77.8	2.9	0.6	14,860
Buchanan County	B	3.5	31.9	60.9	3.7	1.5	14,390
Russell County	B	2.8	34.9	56.5	5.8	0.6	14,150
Wise County	C	2.5	31.7	60.3	5.5	0.5	14,250
Richmond Basin	B	2.8	52.7	62.5	9.0	1.4	13,490

TABLE 13 (*Concluded*)

District	Grade	Moisture	Volatile Matter	Fixed Carbon	Ash	Sulphur	B. T. U.
Washington							
Newcastle District	SuB	12.1	36.8	40.7	10.4	0.3	10,410
Snoqualmie District	B	6.1	22.7	58.8	12.4	0.9	10,710
Ravensdale District	B	7.4	37.4	43.9	11.3	0.5	11,500
Black Diamond District	B	6.8	40.0	47.9	5.3	1.4	12,330
Carbon Hill District	B	3.4	32.2	49.5	14.9	0.5	12,250
Fairfax District	SeB	4.0	18.1	58.5	19.4	0.5	11,820
Roslyn District	B	4.7	36.0	46.8	12.5	0.4	12,240
Cle Elum District	B	5.0	36.1	46.8	12.1	0.4	11,900
Centralia District	SuB	21.0	33.1	36.7	9.2	0.4	8,910
West Virginia							
Wheeling District	B	4.1	36.6	53.3	6.0	2.1	13,400
Fairmont District	B	2.9	34.5	56.9	5.7	0.7	14,040
Clarksburg District	B	2.8	38.5	53.1	5.6	2.4	14,110
Upper Potomac Basin	SeB	1.1	17.2	73.8	7.9	1.1	14,490
Buckhannon District	B	2.5	32.5	56.3	8.7	1.7	13,590
Winfield District	B	5.0	39.6	48.3	7.1	1.8	13,000
New River District	SeB	4.0	14.1	73.7	8.2	0.8	13,850
Beckley District	SeB	4.7	13.0	77.9	4.4	0.8	14,340
Coalburg District	B	3.4	35.2	53.1	8.3	0.7	13,300
Logan District	B	3.3	33.3	58.4	5.0	0.7	14,050
Thacker District	B	3.1	31.4	59.9	5.6	1.2	14,005
Pocahontas Field	SeB	3.4	22.5	68.8	5.3	0.5	14,370
Welch District	SeB	2.8	12.5	80.4	4.3	0.7	14,660
Wyoming							
Sheridan District	SuB	22.6	32.5	40.4	4.5	0.3	9,220
Hanna Basin Field	SuB	11.5	42.6	39.3	6.6	0.4	10,890
Rock Springs Field	B	9.8	34.3	52.5	3.4	1.0	12,260
Kemmerer District	B	5.7	37.7	51.3	5.3	1.4	12,580
Evanston District	SuB	14.4	36.8	41.6	7.2	0.2	10,440

TABLE 14. Coke Production for the Past Decade in Net Tons
From U. S. Geological Survey

Year	Beehive	By-product	Total
1913	33,584,830	12,714,700	46,299,530
1915	27,508,255	14,072,895	41,581,150
1917	33,167,548	22,439,280	55,606,828
1918	30,480,792	25,997,580	56,478,372
1919	19,042,936	25,137,621	44,180,557
1920	20,511,092	30,833,951	51,345,043
1921	5,538,042	19,749,580	25,287,622
1922	8,573,467	28,550,545	37,124,012
1923	17,960,000	37,527,000	55,487,000

TABLE 15. By-products Obtained from Coke-ovens in 1922
From U. S. Geological Survey

Product	Unit	Production	Sales		
			Quantity	Value	
				Total	*Average*
Tar	Gallons	327,779,734	162,204,417	$6,419,743	$0.0396
Ammonia:					
Sulphate	Lb.	695,543,349	714,752,882	17,818,236	0.0249
Ammonia liquor (NH_3 content)	Lb.	50,036,646	48,523,937	4,559,535	0.0940
Other forms (NH_3 content)	Lb.	693,782	192,549	12,041	0.0625
		——	——	22,389,812	——
Sulphate equivalent of all forms	Lb.	898,465,061	909,618,826	——	——
Gas:					
Used under boilers, etc.	M.cu.ft.		19,123,814	1,251,325	0.0654
Used in steel or affiliated plants	M.cu.ft.	[a]442,671,114	144,976,030	15,942,446	0.1100
Distributed through city mains	M.cu.ft.		56,930,253	20,326,648	0.3570
Sold for industrial use	M.cu.ft.		10,352,921	1,104,096	0.1066
			231,383,018	38,624,515	0.1669
Light oil and derivatives:					
Crude light oil	Gallons	[b]101,437,555	5,138,095	630,768	0.1228
Benzol, crude	Gallons	2,666,177	2,665,889	698,437	0.2620
Benzol refined	Gallons	10,419,504	9,590,459	2,736,944	0.2854
Motor benzol	Gallons	57,025,699	54,930,203	10,491,309	0.1910
Toluol, crude	Gallons	38,159	3,938	652	0.1656
Toluol, refined	Gallons	1,955,119	1,906,122	556,363	0.2919
Solvent naphtha	Gallons	2,983,858	2,861,482	538,512	0.1882
Other light oil products	Gallons	580,058	212,712	14,949	0.0703
		75,668,574	77,308,900	15,667,934	0.2027
Naphthalene:					
Crude	Lb.	6,107,742	3,298,851	52,103	0.0158
Refined	Lb.	1,810,972	1,589,084	79,149	0.0498
		7,918,714	4,887,935	131,252	0.0269
Other products	——	——	——	154,507	——
Value of all by-products sold				$83,387,763	

a Includes gas wasted and gas used for heating retorts.
b Of this amount 98,432,100 gallons were refined on the premises to make the derived products listed.
Statistics compiled by H. L. Bennit, Geological Survey, Washington, D. C., Aug. 31, 1923.

TABLE 16. Soft Coal Consumed in the United States and Exported in a Year of Active Business

From U. S. Geological Survey

Type of Consumer	Net Tons	Per cent
Railroads	153,700,000	27.7
Industrials, other than steel and coke	139,100,000	25.1
Steel plants	35,500,000	6.4
Coke:		
Beehive	36,000,000	6.5
By-product	47,740,000	8.7
Public utilities:		
Electric	31,700,000	5.7
Coal gas	4,960,000	0.9
Domestic consumers	57,100,000	10.3
Coal mine fuel	12,100,000	2.2
Exports:		
Canada and Mexico	16,500,000	3.0
Seaborne	9,500,000	1.7
Bunker:		
Foreign trade	6,700,000	1.2
Coastwise and Lake trade	3,600,000	0.6
Total	554,200,000	100.0

TABLE 17. Marketing Methods of the Different Mining Districts

From "Coal Distribution in America" in *The Black Diamond*

District	Percentage Sold Through		
	Sales Departments	Coal Brokers	Sales Agents
Pittsburgh District	Majority (?)		
Somerset County, Pa.	85	5	10
Virginia	50	20	30
West Virginia			
Kanawha District	20	15	65
Logan County	83	11	6
Fairmont District	35	22	43
Pocahontas District	40	0	60
Tug River District	40	25	35 [1]
Tennessee	50	25	25
Kentucky			
Hazard field	37	19	44
Harlan County (Commercial coal)	5	15	80
Northeast Kentucky	25	37	38
West Kentucky	38	28	34
Ohio (Eastern)	60	10	30

[1] These agencies are owned or controlled by the operating companies, but operate under a different name.

TABLE 17 (*Continued*)

District	Percentage Sold Through		
	Sales Departments	Coal Brokers	Sales Agents
Illinois (General)	63	?	?
Southern	75	6	19 [1]
Central	50	25	25
Fulton-Peoria (Commercial)	33	34	33
Northern	Sold mostly	to the rail-	roads
Remainder (about 1,250,000 tons)	85	?	?
Iowa	100	0	0
Southwest	5	7	88
Colorado	90	5	5
Washington	100	0	0

[1] These agencies are owned or controlled by the operating companies, but operate under a different name.

TABLE 18. Contract and Spot Purchases of Bituminous Coal by Class I Railroads in 1919 and 1920, in Net Tons

From Interstate Commerce Commission

Region and Year		Contract	Spot	Total
New England	1920	4,028,518	3,346,023	7,374,541
	1919	3,732,109	1,617,282	5,349,391
Great Lakes	1920	19,488,743	5,088,569	24,577,312
	1919	15,932,076	2,845,864	18,777,940
Ohio-Indiana-Allegheny	1920	28,598,448	8,772,233	37,370,681
	1919	27,327,380	4,291,609	31,618,989
Pocahontas	1920	3,802,532	2,961,299	6,763,831
	1919	4,226,033	1,683,181	5,909,214
Southern	1920	19,857,477	2,997,017	22,854,494
	1919	16,324,108	1,560,451	17,884,559
Northwestern	1920	29,657,381	2,377,455	23,034,836
	1919	15,701,897	1,569,963	17,271,860
Central western	1920	21,670,973	2,347,508	24,018,481
	1919	17,613,338	1,520,517	19,133,855
Southwestern	1920	7,382,473	1,966,986	9,349,459
	1919	6,669,064	1,292,636	7,961,700
Total, all regions	1920	125,486,545	29,857,090	155,343,635
	1919	107,526,005	16,381,503	123,907,508

TABLE 19. Shipments of Bituminous Coal to Tidewater, 1918–1922 (In Net Tons)

	1918		1919		1920		1921		1922	
	Tons	Per Cent	Tons	Per Cent	Tons	Per Cent	Tons	Per Cent	(11 mos.) Tons	Per Cent
By Ports:										
New York	17,091,000	40	14,234,000	38	14,825,000	28	11,912,000	32	7,440,000	26
Philadelphia	3,121,000	7	4,411,000	12	6,191,000	11	3,641,000	10	2,158,000	8
Baltimore	3,641,000	8	3,467,000	9	7,831,000	14	4,136,000	11	1,917,000	7
Hampton Roads	18,977,000	44	14,630,000	40	24,026,000	45	17,242,000	46	16,626,000	58
Charleston	79,000	2	320,000	1	911,000	2	392,000	1	332,000	1
All Ports	42,909,000	100	37,062,000	100	53,784,000	100	37,323,000	100	28,473,000	100
Destination										
Coastwise to New England	15,248,000	36	8,386,000	23	10,457,000	19	8,859,000	23	10,892,000	38
Exports	3,741,000	9	8,292,000	22	21,778,000	41	9,633,000	28	1,613,000	6
Bunker	6,063,000	14	6,874,000	19	9,171,000	17	8,135,000	21	4,577,000	16
Inside Capes	4,476,000	10	3,438,000	9	3,410,000	6	3,251,000	8	3,332,000	12
Other tonnage	13,381,000	31	10,072,000	27	8,968,000	17	7,445,000	20	8,059,000	28
All Destinations	42,909,000	100	37,062,000	100	53,784,000	100	37,323,000	100	28,473,000	100

TABLE 20. Distribution of Lake Cargo Coal (Bituminous) Loaded at Lake Erie Ports*

(In Net Tons)

Destinations	1922	1921	1920	1919	1918
Lake Superior Ports					
Duluth Superior and Two Harbors	5,406,912	8,679,763	7,774,764	7,806,277	10,022,016
Ashland-Washburn	457,944	514,545	604,062	589,705	914,389
Copper Range (1)	602,216	572,738	641,039	776,194	1,427,885
Marquette	233,338	140,596	310,422	233,313	359,989
Ft. William, Pt. Arthur and Jackfish	1,890,918	1,968,322	906,978	1,533,084	2,046,866
Other Lake Superior Ports	11,412	37,750	58,074	61,167	108,091
Totals	8,602,740	11,913,714	11,295,339	10,999,740	14,879,236
Lake Michigan Ports					
Milwaukee-Racine	2,482,401	2,759,327	2,578,085	3,256,650	3,607,347
South Chicago, Ind. Harbor and Gary	1,494,641	1,698,614	1,180,749	1,811,310	1,487,816
Sheboygan to Escanaba (2)	1,341,781	1,493,721	1,500,905	1,413,722	2,037,776
Other Lake Michigan Ports	166,968	220,951	199,780	202,565	273,987
Totals	5,485,791	6,172,613	5,459,519	6,684,247	7,406,926
St. Mary's River Ports					
Detour and Lime Island	584,684	244,943	397,579	196,664	428,460
Sault Ste. Marie, Can.	413,494	751,839	1,092,428	809,548	1,143,096
Sault Ste Marie, American	91,548	90,814	164,915	150,835	159,351
Totals	1,089,726	1,087,596	1,654,922	1,157,047	1,730,907
Lake Huron Ports	197,648	232,483	211,166	297,957	376,268
Detroit & St. Clair River Ports	1,112,325	1,137,140	1,288,970	713,188	1,024,125
Lake Erie Ports					
Buffalo-Fairport and Toledo	1,078,654	244,116	53,758	67,101	131,683
Other Ports (regular)	166,898	91,644	43,422	48,384	42,878
Totals	1,245,552	335,760	97,180	115,485	174,561
Georgian Bay Ports	574,103	766,149	1,008,473	751,583	1,195,328
Welland Canal, Lake Ontario and St. Lawrence River Ports	214,257	766,925	1,392,786	994,094	1,365,966
Grand totals	18,522,142	22,412,380	22,408,355	21,713,341	28,153,317

* Compiled by Ore & Coal Exchange, Cleveland, Ohio; H. M. Griggs, Manager.
(1) Hancock, Houghton, Hubbell, Lake Linden, Portage and Torch Lake.
(2) Escanaba, Green Bay, Marinette, Menominee, Manitowoc and Sheboygan.

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